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The Stirling Water Tube Boiler.

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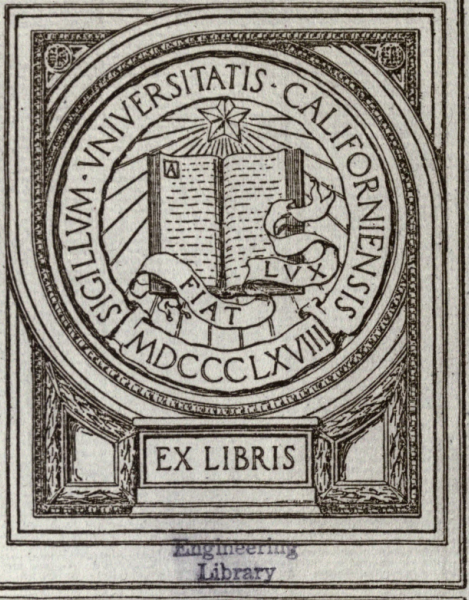

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THE STIRLING SAFETY BOILER.

PACIFIC COAST AGENT.

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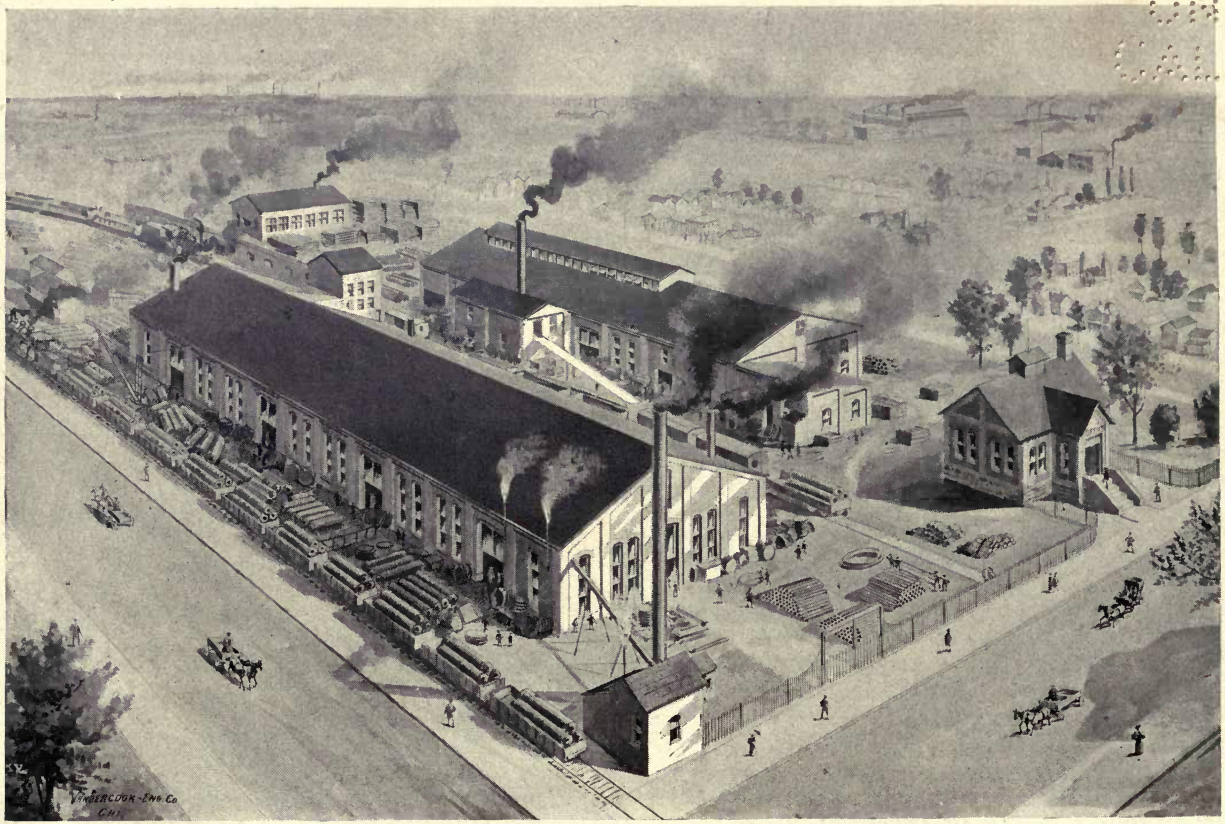

SHOPS AND FOUNDRY OF THE STIRLING COMPANY, BARBERTON, OHIO.

CATALOGUE

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—OF—

THE STIRLING

WATER TUBE SAFETY BOILER

MANUFACTURED BY

THE STIRLING CO.

GENERAL OFFICES:

PULLMAN BUILDING, CHICAGO, ILL.

SHOPS AND FOUNDRIES: - - - BARBERTON, OHIO.

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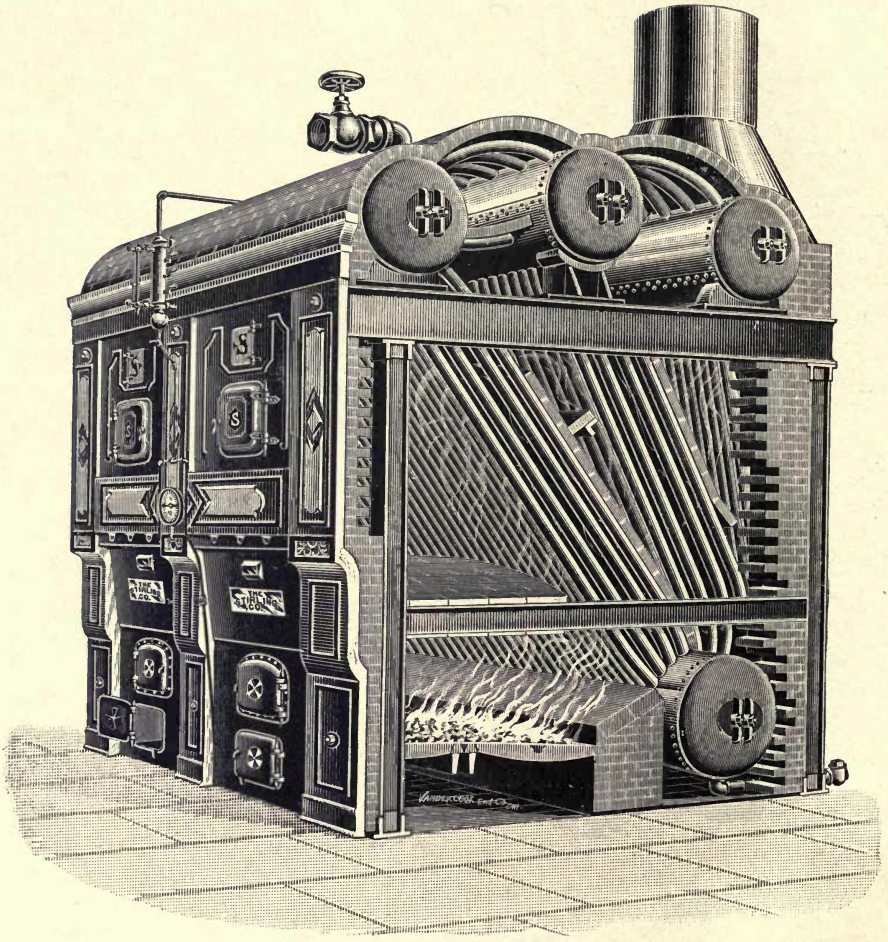

THE STIRLING WATER TUBE SAFETY BOILER.

THE STIRLING SAFETY BOILER.

IT WAS at the Atlantic City meeting of the American Society of Mechanical Engineers, in May, 1885, that Mr. Allan Stirling, a member of the Society, announced privately that he had designed a boiler, which he thought would make its mark in the world. He gave no description of its design, except to say that it would overcome all the objections which had been raised against boilers of the prevailing types, and that it had many advantages peculiar to itself. The incident was forgotten until a few years later, when the International Boiler Company, Limited, of New York, placed the Stirling Boiler on the market and offered it to the public.

The first boilers of this type consisted merely of two upper drums and one lower or mud drum. They were crudely constructed, and in their erection little attention was paid to the minor details, which are of such great importance in the aggregate, in determining the character of a boiler plant. Crude, however, as these first boilers were, they demonstrated conclusively that the theory of the inventor was a good one, and indicated that great possibilities lay in the development of his principle.

With these points established, the Stirling Company was formed, and its energies and attention were immediately concentrated upon the work of perfecting the Stirling Boiler. Its construction was elaborated, but the principle was, and always has been, the same; a third, or feed drum, was added; the plan of setting was modified; and one improvement after another was made, until finally it may be said, with truth, that everything that is known in the art, or that years of experience and thought can suggest, has been

adopted to enable the Stirling Boiler to meet every demand and fulfill every requirement.

The success attending its introduction has been noteworthy, and if any evidence be needed to support the claims of the manufacturer, it will be found in the record of its sales. Novelty wears off after awhile, and any mechanical product, to obtain a permanent growth and position, must have merit as well as the charm of being a departure from old and established standards. The Stirling Boiler has not only retained the good-will of those who accorded it so warm a reception when it was first placed on the market, but it has also made hosts of friends, and is making more every day. During a period of about five years, the sales in horse power have aggregated 350,000 H. P., and, what is all the more significant, each year shows a healthy gain over the preceding.

CONSTRUCTION.—The boiler consists, briefly, of three upper or steam drums, and one lower or mud drum, all connected together by means of tubes, which are bent slightly, so as to allow them to enter the drums normal to their periphery. All of the upper or steam drums are connected by steam circulating tubes, but the front and middle drums only are connected by water circulating tubes. The tubes used are $3\frac{1}{4}$ inches in diameter, and are made of the best lap-welded mild steel, and are subjected to a cold water pressure test of 1,500 pounds per square inch. The material used in the manufacture of the drums is the very best quality of flange steel. These drums and tubes form the boiler proper, so it will be seen that no cast metal is used at all. This extreme simplicity of construction must be obvious to all.

ACCESSIBILITY.—No other water tube boiler possesses the feature of accessibility in so marked a degree as the Stirling. This statement applies not only to the interior surfaces, but to the exterior surfaces as well. In most of the water tube boilers, and noticeably in some of the nondescript productions that have made their appearance in recent years, the tubes are

arranged in clusters, and, as a rule, are staggered; that is, one tube lies opposite the space between two in the next row. In the Stirling Boiler the tubes are in rows four deep only, and all tubes are laid out in parallel rows. It is possible to pass the hand, and, indeed, the whole arm, between two rows of tubes and reach those in the fourth or last tier—a thing impossible to do in any of the prominent boilers of the horizontal water tube type, or in any boiler in which the tubes are staggered. This arrangement of the tubes enables the exterior surfaces to be thoroughly cleaned of soot and kindred deposits. Such a result can be accomplished only with the greatest difficulty in the case of the staggered tubes common in many other boilers.

As to the accessibility of the interior surfaces, the removal of four man-hole plates exposes to view the two ends of every tube in the boiler, and, for all practical purposes, the entire area of the interior heating surface. The boiler attendant, or cleaner, can then enter the drums, one by one, and remove the mud and other deposits, scraping the tubes from end to end if need be (using a chain or jointed scraper for that purpose), the whole operation being so simple and so easily accomplished that the most ignorant laborer, with a few instructions, can perform it acceptably.

The time and labor necessary to open, examine and clean the Stirling Boiler, with but four man-hole plates to remove, is in striking contrast to that required by one of the horizontal water tube boilers, having, say, three hundred caps and gaskets (always a source of extreme annoyance, expense and leakage) to remove, the surfaces of their seats to clean, and the whole number to replace and make tight before the boiler can be again put under steam. Moreover, the tubes in the horizontal type are so slightly inclined that the tendency of sediment to precipitate in them is, obviously, very much greater than in the tubes of the Stirling, which are but slightly inclined from the vertical.

REPAIRS.—Owing to its simplicity of construction, and to its great accessibility, it follows that the Stirling is readily and easily kept in repair. If a tube end leaks, it is but a few minutes work to open the drum, introduce an expander, and roll the tube. If a tube must be replaced, it can be quickly removed and a new one substituted, and, under the most adverse conditions, it is never necessary to destroy more than one perfect tube to reach a defective one. This simple method of removing tubes, without having to withdraw them through holes in the tube sheet, is a valuable advantage, and is in marked contrast to the troublesome methods of other types of boilers, where, in case of the rupture of a tube and its consequent distention, it can neither be withdrawn through the hole in the sheet or header, nor passed through the spaces of the surrounding tubes, and its removal can only be accomplished by cutting away the intervening tubes.

Further, there are in the Stirling but four man-hole joints to keep tight, and but four gaskets to renew from time to time. Contrast this with the two hundred and fifty or three hundred hand-hole plates that must be kept tight, and the corresponding number of gaskets that are continually wearing out in a boiler of the horizontal type.

SAFETY.—Purchasers, as well as users, of boilers lose sight, too often, of the enormous energy contained in steam and water at a high temperature under pressure; of the fact that a cubic foot of hot water, under a pressure of sixty to seventy pounds per square inch, has about the same energy as one pound of gunpowder; and that the power contained by the mechanical energy in boilers is enough to project them enormous distances. Whilst mystery surrounds many boiler explosions, there is no doubt that all disruptive explosions occur only when the energy contained in the steam and water confined in the boiler is *suddenly* liberated.

If a rupture occurs in the shell of a tubular, flue, or cylindrical boiler, the entire energy of the steam and water within

is suddenly released, resulting in the destruction of the boiler itself, and frequently of its surroundings, with accompanying loss of life. The same disastrous consequences attend a rupture in a water tube boiler when the part giving way contains a large quantity of steam and water. Thus, the bursting of headers in the horizontal type of water tube boilers is frequently accompanied by most destructive results, owing to the fact that, although they do not in themselves contain large volumes of water, they are connected with a number of tubes, which, in the aggregate, contain a very large quantity of water; and, when the cast iron gives way, the rupture is not confined to a single spot, but generally extends throughout the entire length of the header, thus instantly liberating the water and steam of all the tubes expanded into it. A rupture in cast iron must, of necessity, extend throughout its entire length or breadth; whilst a rupture in wrought iron, or soft steel, is mostly local, and can only be enlarged by a continued application of force. None of the so-called "safety boilers," then, in which cast iron is used, are worthy of the name; the term can only be applied to boilers in which the only possible points of rupture are confined to portions containing small masses of water, and which are constructed of a material in which such rupture will remain local.

The character of the materials used, the workmanship, and the design of the Stirling all tend to render it an absolutely safe boiler. As has been pointed out elsewhere, no cast metal whatever is used in its construction. Thus is eliminated an evil that has proven fruitful of most disastrous explosions in other types of water tube boilers, in which cast iron headers are used. There is, further, in the Stirling, an entire absence of flat surfaces under pressure; no riveted joints exposed to the action of the fire; no stay-bolts; and, finally, the circulation is so rapid as to maintain a uniform temperature in all of its parts, thus doing away with the excessive strains due to unequal expansion and contraction.

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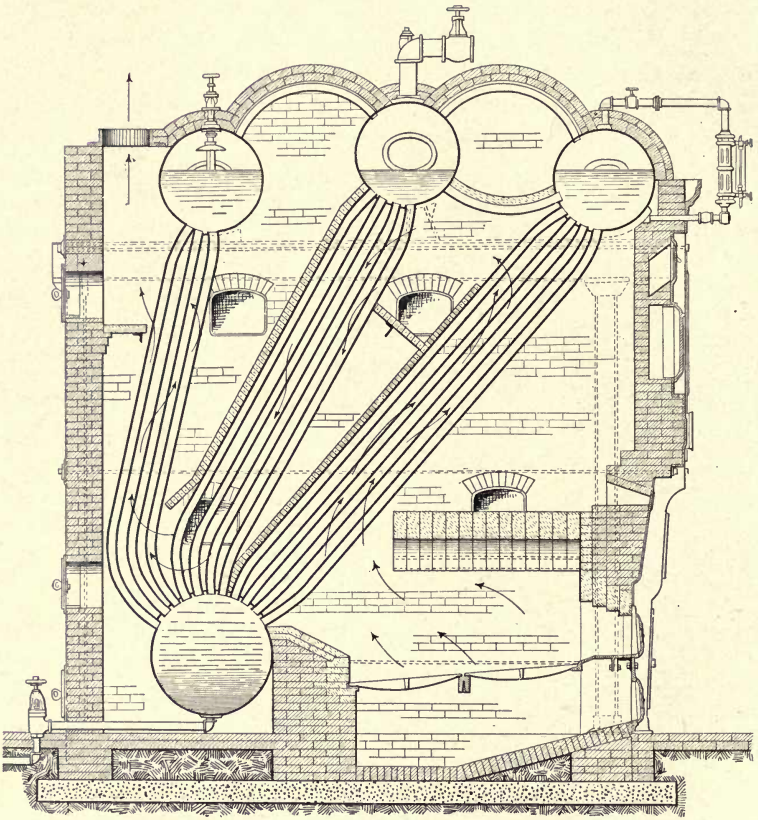


SECTIONAL VIEW OF STIRLING BOILER.—SIDE ELEVATION.

Complete Combustion.—By reference to the sectional view of the Stirling Boiler, it will be seen that there is a fire-brick arch sprung over the grates, and immediately in front of the first section of tubes. The advantage arising from this arch cannot be overestimated. It absorbs heat generated by the fire on the grates, and becomes an incandescent radiating surface precisely after the fashion of the roof of a reverberatory furnace with the advantages that:

First. It heats to a high temperature the air which is admitted when the furnace doors are opened for charging or cleaning. This greatly prolongs the life of the boiler, as it prevents the contact of cold air with the tubes, which in other designs produces sudden contractions and expansions, and ultimate crystalization.

Second. It ignites by radiation the upper surfaces of the new fuel, as it is fed upon the incandescent coal upon the grates, thus preventing the chilling of the fires, and maintaining a comparatively uniform temperature of the gases as they pass from the furnace to the tubes. For this reason alone, a given quantity of grate surface is more effective in the Stirling than in boilers of other designs.

Third. It insures an even distribution of the gases, owing to the fact that the falling away of the arch from the center to the sides, obviates the possibility of the concentration of the gases at any one point, and results in a uniform contact of the gases, at their highest initial temperature, with the tubes.

By further reference to the views of the boiler, it will be seen that, in addition to having, by the use of an incandescent arch, provided for the thorough combustion of the fuel, provision has been made for the absorption of the greatest possible proportion of the heat contained in the gases, by compelling them to make three passes in their course through the furnace; first, up the front bank of tubes, then down the middle bank of tubes, and, finally, up the rear bank of tubes,

after which they escape to the smoke-stack at a greatly reduced temperature.

Again referring to the sectional views of the boiler, it will be seen that this construction admits of a more thorough adjustment of grate service to heating surface than any other boiler on the market. This feature is one that will commend itself at once to those who have made the question of combustion a study; for, just as the constituent elements of different coals differ, so, in like manner, is it necessary to adjust the conditions under which they are to be consumed. The Stirling Boiler admits of the greatest possible elasticity in this direction, as its grate surface can be either increased in depth and width, as may be required; or, on the other hand, may be reduced in one direction or the other, without in any way affecting the construction of the boiler.

Attention should also be directed to the fact that, as the Stirling Boiler is increased in size, the water and steam space increases in the same ratio. This can be said of no other boiler on the market.

HANDLING IMPURE WATER.—The feature which above all others characterizes the Stirling Boiler is the ability it possesses of separating the mineral and other ingredients of impure water, thus preventing the formation of scale on the interior surfaces. As a practical example, we refer to an investigation that was made some time since of a boiler plant consisting of Stirling and water tube boilers of the horizontal type. We quote from the expert's report, as follows: "The boilers were installed side by side; both were fed from the same water supply, and operating under the same conditions. The Stirling contained no visible scale and little deposit of any kind after one year's work and one cleaning; whilst the other boiler contained scale varying in thickness from $\frac{1}{8}$ to $\frac{3}{8}$ inches after two months' use since last cleaning. The labor of cleaning the Stirling Boiler during the year required only six minutes time for each horse power, while the cleaning of

the horizontal water tube boiler required one hour and thirty minutes for each horse power per year. *No less, then, than fifteen times as much labor was required upon the horizontal water tube boiler as was required upon the Stirling.* The water contains carbonate of lime in considerable quantity and traces of sulphate of lime."

The marked adaptability of the Stirling Boiler to the use of impure feed water is due to an arrangement whereby the feed water enters the rear upper drum, the coolest part of the boiler, and its temperature is gradually raised to the steaming point, by the escaping gases, in its descent through the rear bank of tubes to the mud drum below. The mud drum is protected from the fierce heat of the furnace by an ample bridge wall, and acts as a most excellent settling chamber,—the circulation in that portion of the boiler being comparatively slight. Reaching the mud drum, the chemical impurities, which have become insoluble under the action of the high temperature, descend to the bottom in the form of sludge or mud, and can be blown out as frequently as may be found necessary. Should any of the precipitate collect in the rear bank of tubes, the heat of the gases is so reduced by the time they reach that part of the boiler, that the deposit is not baked hard, as it would be in the front bank of tubes, but remains in a soft, plastic condition, and may be readily washed off with a hose or easily removed with a scraper. The front and middle banks of tubes, therefore, through which rapid circulation takes place, are filled with water which has been purified. This rapid circulation and the purification of the water reduces the danger of scale formation to a minimum, so that the interior of the tubes remaining clean, heat is transmitted more rapidly and efficiently, thus adding greatly to the economy of the boiler. The Stirling Boiler is the only steam generator in which this feature of being particularly adapted to the use of impure feed water is so well carried out.

DRY STEAM.—The circulation of the Stirling Boiler is rapid and thorough; not choked nor intermittent as in other types. It naturally follows that the steam liberated at the surface of the water in the drums is unmixed with entrained water, and is "dry." Any contraction of area at the point where the steam leaves the tubes and enters the drums, must result in a squirting, or geyser-like action, which projects a mixture of spray and steam into the steam space above the water.

Most water tube boilers contain headers, entering into which are a number of tubes, and each header is connected to a main steam drum by an opening having an area of but ten to fifteen per cent of the combined area of the tubes, and through which all the circulating water and steam must pass. The geyser-like action, above referred to, is the unavoidable result in such boilers, and to so great an extent in some designs, that an effort is made to modify this action by the insertion of baffle plates, steam dryers, or similar devices. The Stirling, on the other hand, has an unrestricted circulation; there is a free passage of water from one bank of tubes to another; each tube has a separate outlet equal to its area, and the tubes are but slightly inclined from the vertical; all of which conduces to the free liberation of steam at the surface of the water in the drums, and insures its being dry.

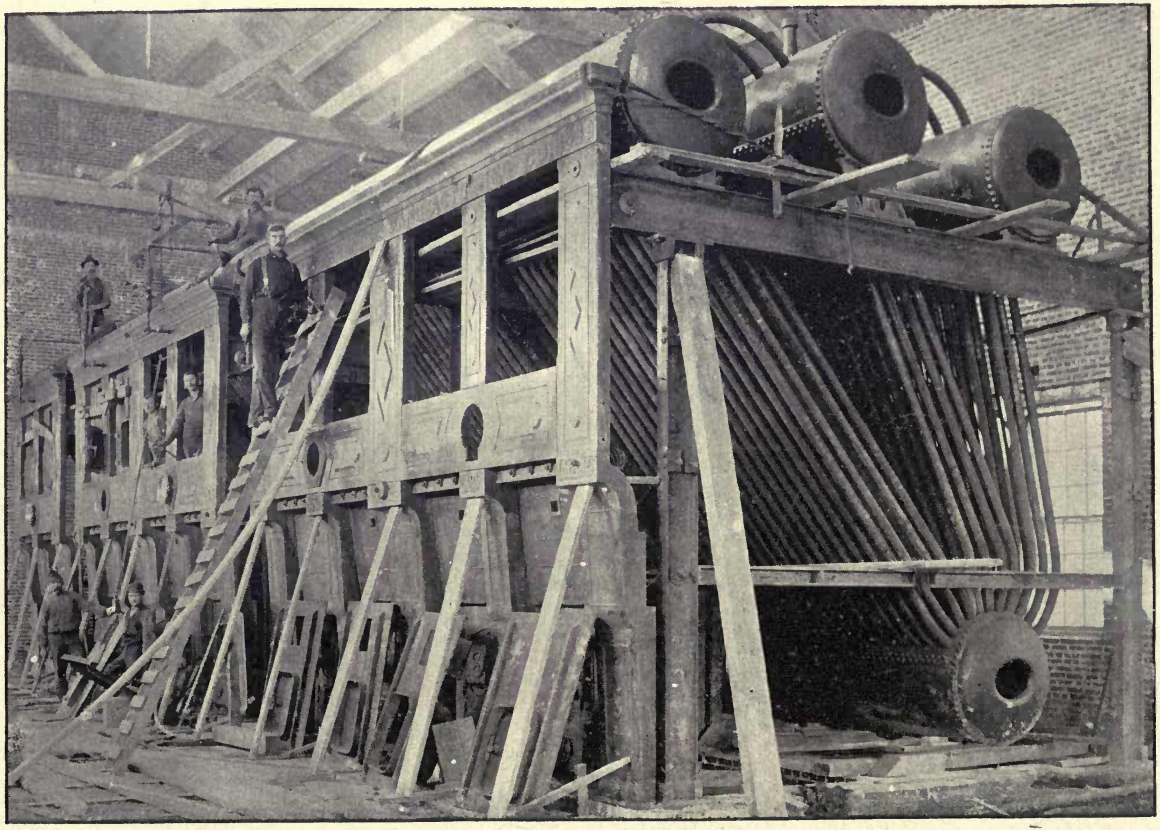
WORKMANSHIP.—It is not generally known that there are but two or three concerns engaged in the water tube boiler business that manufacture their own boilers, and that all the others are virtually mere sales agents, as the boilers sold by them are either manufactured entirely under contract, by boiler makers in different parts of the country, or else they have the various parts of the boilers, namely, drums, tubes and castings, manufactured by different concerns, and they merely assemble the parts and prepare them for shipment. The disadvantage arising from this method of doing business will be readily appreciated, for, no matter how earnest and anxious the dealer may be to guarantee the work-

manship and material of his boiler, he is dependent for his guarantee entirely upon others who have not the same interest in the operation of the boiler that he has, but whose interest, on the contrary, ceases the moment their portion of the work is completed and their bill paid. The Stirling Company, on the other hand, owns and operates its own shops and foundry; every part of the boiler is designed by its own engineers and manufactured under their supervision; all the material used is carefully tested by its own men; and every precaution that years of experience can suggest is taken to insure that the material, as well as workmanship, of the boiler is of the highest grade obtainable. Every boiler before being shipped is tested at 200 lbs. cold water pressure, and, after erection and all parts are in place, it is again submitted to a 200 lbs. cold water pressure. It will, therefore, be seen that the Stirling Company is in a most excellent position to make good its guarantee on the workmanship and material of the boilers manufactured by it.

SETTING.—In the setting every care that years of experience and observation have suggested is taken. The boiler is sustained entirely independent of the brickwork, so that the brickwork may be removed or replaced without disturbing the boiler or its connections. The three upper or steam drums are supported by wrought iron beams, resting on wrought iron columns, with cast iron bases properly secured, whilst the mud drum is suspended and left free to allow for contraction and expansion.* In no other boiler is this feature so prominent. Owing to this arrangement, the varying temperatures, extending from about 500° F. at the out-take of the stack to 2,000° F. or more at the furnace, produce no such strains and consequent leakages in the Stirling as they do in

* As an evidence of the direct advantages resulting from this manner of supporting the Stirling Boiler, we refer to a recent explosion of natural gas in the furnace of a Stirling Boiler at the American Tin Plate Company's plant at Elwood, Ind. Although the force of the explosion was sufficient to entirely demolish the brickwork, the boiler was uninjured in any way whatever. The brickwork was replaced, and the boiler placed in commission, without it having been necessary to make any repairs whatever to the boiler proper.

PACIFIC COAST AGENT.



1000 H. P. STIRLING BOILERS IN PROCESS OF ERECTION AT WHITMAN & BARNES MFG. CO., WEST PULLMAN, ILL.

the horizontal type, in which the absolutely straight tubes are expanded into rigid headers, and no provision whatever is made for the expansion and contraction incident to these great differences of temperature.

DIMENSIONS.—The Stirling is built to meet the varying requirements of height, width and depth, so that a 200 horse-power boiler can be built to occupy from 12 to 20 feet in height, 10 to 15 feet in width, and 14 to 17 feet in depth. It is, therefore, equally well adapted to boiler rooms having low ceilings and ample width, as well as to those having little width and ample height.

EFFICIENCY AND CAPACITY.—In the point of evaporative efficiency and capacity the Stirling is unexcelled, as numerous evaporative trials have proven. Attention is respectfully called to the table of tests on page 56. It will be seen that the boiler in tests for economy has evaporated as high as 12.49 lbs. of water, from and at 212°, per pound of combustible, whilst in capacity tests it has been forced as high as 133 per cent above its rating, and the steam under these conditions has contained but one-half of one per cent moisture.

THE CIRCULATION OF WATER IN THE STIRLING BOILER.

WHEN water is heated in a vessel or chamber of considerable size, by fire placed underneath, the water which is warmed by the transfer of heat through the bottom of the vessel, becomes specifically lighter than the remainder of the water, and in consequence rises to the surface. Its place is taken by cooler fluid which is heated in turn and rises in like manner. Thus a gentle circulation is set up, which results in keeping the coolest water always in contact with the heating surface. This operation is favorable to the transfer of heat from the fire to the water, by reason of the fact that the greater the difference of temperature between the fire and the fluid to which heat is being communicated, the more rapid will be the transfer of heat.

When the temperature of the water reaches the boiling point, the heat of the fire no longer raises its temperature, but, instead, it vaporizes a portion of the water. In consequence, there is no difference in the specific gravity of the water in different parts of the vessel available for producing a circulation. The steam which is formed rises through the water and escapes at the surface, but there is little or no movement of the water as a whole.

If, however, as Mr. Geo. W. Babcock has written, we "take a U shaped tube, depending from a vessel of water (Figure A), and apply a lamp to one leg, a circulation is at once set up within it." This circulation not only continues after steam begins forming, but becomes more rapid in proportion as the rapidity of evaporation increases. The explanation of this

action is a follows: When steam is formed rapidly in a long vertical tube, it does not rise independently of the water as in the case of a large vessel, but it carries along with it the water with which it is intermingled. The effect is the same as if the mingled water and steam were replaced by a single fluid of uniform density, equal to the average density of the mixture of steam and water. It follows that the density of the fluid in the vertical tubes will be less as the proportion of steam to water is greater. If one leg of the tube is exposed to hotter furnace gases than the other, then a greater relative amount of steam will be generated in it, and the average density of the mixture of steam and water will be correspondingly less. Consequently, a vigorous circulation will be produced by the difference in density between the two columns. In accordance with a well known law, the force which produces the circulation increases with the height of the balancing columns of fluid. Consequently, a water tube boiler, with vertical or nearly vertical tubes, other things being equal, will have a stronger circulation than a boiler with slightly inclined tubes; while a water tube boiler with perfectly horizontal tubes, with a diameter relatively small as compared to their length, would have no circulation at all, as the steam formed would simply drive the water in both directions away from the heated portion.

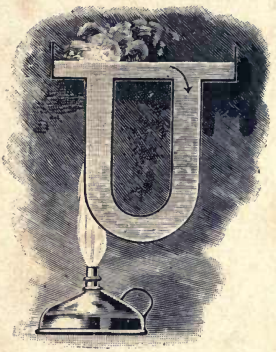


FIGURE A.

Another requisite for a vigorous circulation is that there be a free passage for the water from one bank of tubes to the other. If the water be throttled in any part of its course, the strength of the circulation will be diminished to that extent,—especially should there be a free passage from the upper ends of the tubes to the surface of the water, because here the volume of the steam is much greater by reason of the presence

of the escaping steam bubbles, which occupy a much greater volume than they did previously as water.

These conditions are admirably fulfilled in the Stirling Boiler, as can be observed by consulting Figure B. Here we have the identical arrangement illustrated in Figure A.

The tubes D D′ correspond to the legs of the U shaped tube, while the drums A B, being connected by the tubes E, correspond to the chamber above. Hotter furnace gases are applied to the tubes D′ than to the tubes D; the tubes are nearly vertical; the flow of water in completing the cycle from C to B to A to C is unrestricted. *All the theoretical conditions for a vigorous and rapid circulation are therefore present in the Stirling Boiler.*

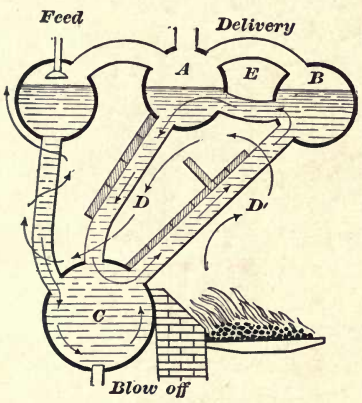


FIGURE B.

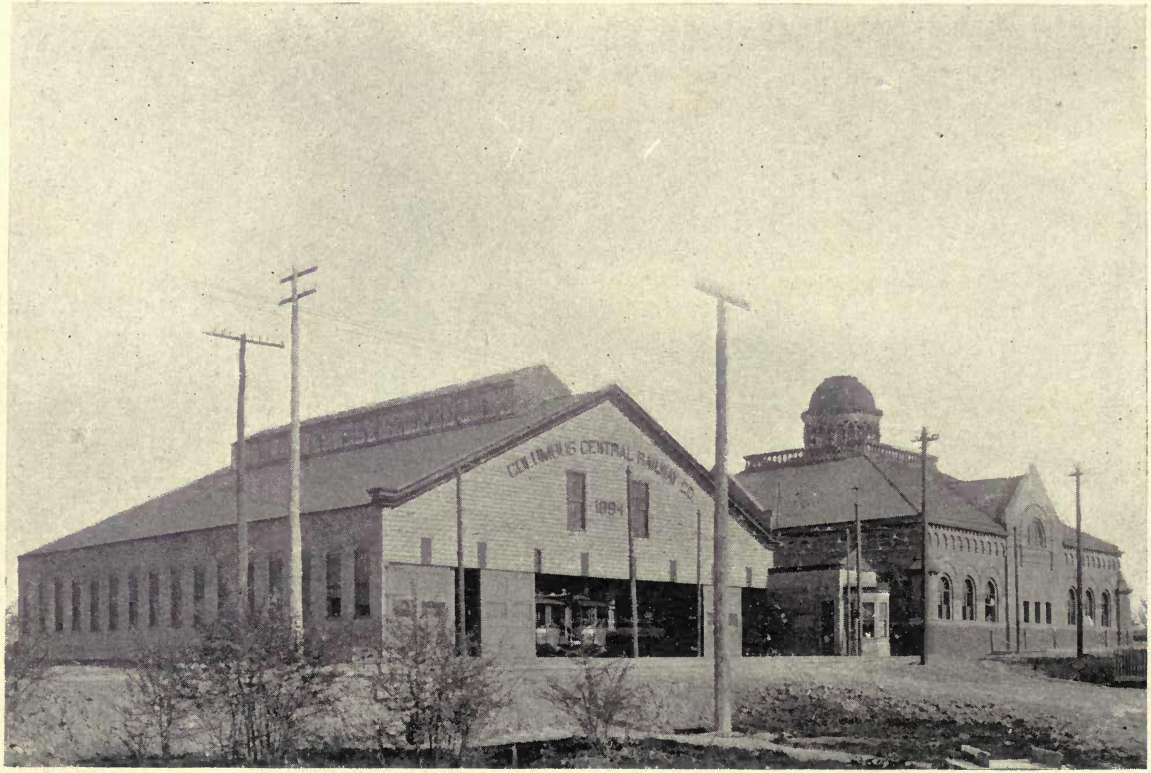
Rankine, in his Treatise on the Steam Engine, Chapter I, Section 3, Article 220, says: "When heat is to be transferred by convexion from one fluid to another, through an intervening layer of metal, the motion of the two fluid masses should, if possible, be in opposite directions, in order that the hottest particles of each fluid may be in communication with the hottest particles of the other; and that the minimum difference of temperature between the adjacent particles of the two fluids may be the greatest possible; * * * * in the steam boiler that is favorable to economy of fuel, the motion of the water and steam should, on the whole, be opposite to that of the flame and hot gas from the furnace; * * * * the coolest portions of the water in the boiler should, if practicable and convenient, be contiguous to the coolest parts of the furnace and heating surfaces."

These are the theoretical conditions governing the highest

economy obtainable in the steam boiler, and, here again, it will be seen that the Stirling fulfills all theoretical requirements. The feed water enters the rear upper drum ; thence it passes down the rear bank of tubes to the mud drum ; during its passage from the rear upper drum to the mud drum, the water is heated within a few degrees of that in the front banks of tubes, and it *moves in a direction opposite to that of the furnace gases*, which pass into the stack at the point where the coolest water enters the boiler.

Before the advent of the Stirling, the principle developed above had been employed in the so called Economizer ; but, by no designer, had it been successfully incorporated in the boiler itself.

PACIFIC COAST AGENT.



POWER HOUSE COLUMBUS CENTRAL RY. CO., COLUMBUS, O., IN WHICH 800 H. P. STIRLING BOILERS ARE INSTALLED.

INCRUSTATION OR SCALE.

MOST natural waters contain more or less scale-forming salts, and in many localities the problem of the prevention and removal of the deposit of scale in steam boilers is a very serious one. If the water which is being used contains salts of lime or magnesia, these salts, which are mostly insoluble in water at 300° Fahr., will be deposited as solid matter upon the inner surfaces of the boiler, forming a coating which interferes seriously with the transmission of heat. It has been found that if feed water, in contact with the heating surfaces where steam is being formed, be kept in rapid motion, scale will not be deposited, save to a limited extent.

It is evident that opportunity must be afforded for the deposit of these precipitations somewhere. The best that can be done is to compel them to be deposited in some part of the boiler where they will be least objectionable, and where they can be readily removed.

The parts of the boiler in which the formation of scale should be prevented, if possible, are those parts which are exposed to the hottest furnace gases, for the reason that these parts are the most efficient in transmitting heat, as well as because the scale matter becomes harder and more difficult to remove than when deposited in parts of the boiler subject to lower temperature.

The evil effects of scale are due to the fact that it is relatively a non-conductor of heat, and its presence, consequently, will greatly diminish the amount of heat transferred from the furnace gases to the water. It has been demonstrated that scale one-sixteenth of an inch thick causes a loss of about fourteen per cent of fuel, while the loss resulting from a half inch thickness of scale has been estimated as high as sixty per cent; the ratio increasing as the scale grows thicker. To illustrate: to raise steam to a pressure of ninety pounds, the

water must be heated to 320° Fahr.; if the boiler be clean, this may be done by heating the exterior surfaces to 325° Fahr., but, if one-half inch of scale intervene between the shell and the water, its non-conductivity is so great that it will be necessary to raise the heating surfaces to a temperature of nearly 700°. At this high temperature the strength of the metal is greatly diminished, and consequently the boiler is liable to bulge and to give way under the pressure from within, resulting, in fire tubular boilers, in disastrous explosions, and, in the water tube types, in the rupture of tubes. The rupture or collapse of sheets or tubes from overheating or burning of the metal is more frequently caused by scale formation than by lack of water.

The efficiency, as well as the life, of a boiler, then, demands that the formation of scale be prevented in those parts subject to the highest temperature. The Stirling admirably fulfills these conditions, in that the feed water, before being admitted to the main circulation, is, in its descent from the feed drum to the mud drum, heated to a point at which the scale-forming salts are rendered insoluble, and are, consequently, precipitated in the mud drum, and may be blown off as frequently as may be found necessary. Further, the nearly vertical tubes of the Stirling Boiler are of great advantage in allowing the precipitations an uninterrupted descent to the mud drum. Moreover, the current of the main circulation, in passing through the front and middle banks of tubes, moves with considerable velocity, tending to lessen, if not entirely prevent, the deposit of scale on heating surfaces exposed to the hotter furnace gases. This results in certain distinct advantages: First, the heating surfaces remain free from scale and transmit heat more rapidly and efficiently. Second, the surfaces, being free from scale, are not liable to be burned, and are, consequently, more durable. Third, the freedom from scale conduces to a more uniform and uninterrupted circulation.

STEAM TABLES AND THEIR USES.

STEAM gauges are so designed that at the normal pressure of the atmosphere the needle points to zero. This normal is, approximately, 14.7 pounds per square inch, and at this pressure water boils at 212° F. The boiling point of water and all liquids varies with the pressure; thus, at 10 pounds below atmospheric pressure, the boiling point of water is 160°, while at 10 pounds above it is 239°; at 100 pounds above it is 338°.

Heat is measured by the change of temperature it produces in a given weight of any substance. *A British Thermal Unit* is that amount of heat which will raise the temperature of one pound of water one degree F., at its point of maximum density, 39° F. The amount of heat required to raise one pound of water through successive degrees is not constant. Thus, to raise the temperature of water 8° above freezing point* requires 8.06 thermal units; while to raise the temperature of water 108° above freezing point requires 108.22 thermal units; from which it may be seen that the amount of heat absorbed increases somewhat more rapidly than the temperature. The quantity of heat contained in water at a given temperature, in excess of that contained in the water at 32° F., is called the "*heat in liquid.*" If heat be applied to water already at the boiling point, no increase of temperature will result,—the heat absorbed being employed in transforming the water from liquid to steam. This is called the "*heat of vaporization.*" The amount of heat thus absorbed, at various pressures and temperatures, has been determined experimentally, and it has been found that the "*heat of*

*Water below 32° becomes ice, which follows another law.

TABLE I.

TABLE OF THE PROPERTIES OF SATURATED STEAM.

Gauge Pressure in lbs. per Square Inch.	Temperature in Degrees F.	Total Heat in Heat Units from Water at 32° F.	Heat Units in Liquid from 32° F.	Heat of Vaporization in Heat Units.	Density or Weight of 1 Cubic Foot in lbs.	Volume of 1 lb. in Cubic Feet.	Weight of 1 Cubic Foot of Water.
0	212.00	1146.6	180.8	965.8	0.03760	26.60	59.76 (Formula) 59.64 (Observed)
10	239.36	1154.9	208.4	946.5	0.06128	16.32	59.04
20	258.68	1160.8	227.9	932.9	0.08439	11.85	58.50
30	273.87	1165.5	243.2	922.3	0.1070	9.347	58.07
40	286.54	1169.3	255.9	913.4	0.1292	7.736	57.69
50	297.46	1172.6	266.9	905.7	0.1512	6.612	57.32
55	302.42	1174.2	271.9	902.3	0.1621	6.169	57.22
60	307.10	1175.6	276.6	899.0	0.1729	5.784	57.08
65	311.54	1176.9	281.1	895.8	0.1837	5.443	56.95
70	315.77	1178.2	285.6	892.7	0.1945	5.142	56.82
75	319.80	1179.5	289.8	889.8	0.2052	4.873	56.69
80	323.66	1180.6	293.8	886.9	0.2159	4.633	56.59
85	327.36	1181.8	297.7	884.2	0.2265	4.415	56.47
90	330.92	1182.8	301.5	881.5	0.2371	4.218	56.36
95	334.35	1183.9	305.0	879.0	0.2477	4.037	56.25
100	337.66	1184.9	308.5	876.5	0.2583	3.872	56.18
105	340.86	1185.9	311.8	874.1	0.2689	3.720	56.07
110	343.95	1186.8	315.0	871.8	0.2794	3.580	55.97
115	346.94	1187.7	318.2	869.6	0.2898	3.452	55.87
120	349.85	1188.6	321.2	867.4	0.3003	3.330	55.77
125	352.68	1189.5	324.2	865.3	0.3107	3.219	55.69
130	355.43	1190.3	327.0	863.3	0.3212	3.113	55.58
135	358.10	1191.1	329.8	861.3	0.3315	3.017	55.52
140	360.70	1191.9	332.5	859.4	0.3420	2.924	55.44
145	363.25	1192.8	335.2	857.5	0.3524	2.838	55.36
150	365.73	1193.5	337.8	855.7	0.3629	2.756	55.29
155	368.62	1194.3	340.3	853.9	0.3731	2.681	55.22
160	370.51	1195.0	342.8	852.1	0.3835	2.608	55.15
165	372.83	1195.7	345.2	850.4	0.3939	2.539	55.07
170	375.09	1196.3	347.6	848.7	0.4043	2.474	54.99
175	377.31	1197.0	349.9	847.1	0.4147	2.412	54.93
180	379.48	1197.7	352.2	845.4	0.4251	2.353	54.86
185	381.60	1198.3	354.4	843.9	0.4353	2.297	54.79
190	383.70	1199.0	356.6	842.3	0.4455	2.244	54.73
195	385.75	1199.6	358.8	840.8	0.4559	2.193	54.66
200	387.76	1200.2	360.9	839.2	0.4663	2.145	54.60

From Peabody's Tables.

vaporization" diminishes as the pressure and temperature increase.

The "*heat in liquid*," plus the "*heat of vaporization*," is called the "*total heat.*"

The performance of boilers is determined by the number of pounds of water evaporated per hour; and, knowing the actual amount of water evaporated, it is customary among engineers to calculate what amount would have been evaporated, by the same quantity of fuel, under the normal atmospheric pressure, with feed water at 212° F. This is technically expressed by the term, "*from and at 212°.*"

Vapor at the instant of its formation, is said to be saturated. In this condition it exactly contains all of the heat which the liquid contained, plus the "*heat of vaporization:*" no more; no less. If the pressure be maintained constant, and heat be added to the vapor, it is said to be "*superheated.*"

Table I gives the properties of saturated steam from 0 to 200 pounds gauge pressure.

Table II gives the "*heat in liquid*," and the specific weight in pounds per cubic foot of water at different temperatures between 32° and 212° F.

Table III gives the values of the "*Factors of Evaporation*" for different conditions of steam pressure and feed water temperature.

The "*Factor of Evaporation*" is the ratio of the amount of heat required to make one pound of steam under any given conditions, to that required to make one pound of steam "*from and at 212°*," and is obtained by finding the "*total heat*" utilized in evaporating the water under given pressure of steam and temperature of feed, and dividing by 965.8, which is the "*heat of vaporization*," or the number of heat units required to evaporate one pound of water at 212°. For instance, if in a certain case the steam pressure is 70 pounds by the gauge, and the feed water 100° F., the amount of heat

TABLE II.

WATER BETWEEN 32° AND 212° F.

Temperature. Fahr.	Heat Units per lb.	Weight, lb. per cubic ft.	Temperature. Fahr.	Heat Units per lb.	Weight, lb. per cubic ft.	Temperature. Fahr.	Heat Units per lb.	Weight, lb. per cubic ft.
32°	0.00	62.42	123°	91.09	61.68	168°	136.45	60.81
35	3.02	62.42	124	92.10	61.67	169	137.46	60.79
40	8.06	62.42	125	93.10	61.65	170	138.46	60.77
45	13.08	62.42	126	94.11	61.63	171	139.47	60.75
50	18.10	62.41	127	95.12	61.61	172	140.48	60.73
52	20.11	62.40	128	96.13	61.60	173	141.49	60.70
54	22.11	62.40	129	97.14	61.58	174	142.50	60.68
56	24.11	62.39	130	98.14	61.56	175	143.50	60.66
58	26.12	62.38	131	99.15	61.54	176	144.51	60.64
60	28.12	62.37	132	100.16	61.52	177	145.52	60.62
62	30.12	62.36	133	101.17	61.51	178	146.53	60.59
64	32.12	62.35	134	102.18	61.49	179	147.54	60.57
66	34.12	62.34	135	103.18	61.47	180	148.54	60.55
68	36.12	62.33	136	104.19	61.45	181	149.55	60.53
70	38.11	62.31	137	105.20	61.43	182	150.56	60.50
72	40.11	62.30	138	106.21	61.41	183	151.57	60.48
74	42.11	62.28	139	107.22	61.39	184	152.58	60.46
76	44.11	62.27	140	108.22	61.37	185	153.58	60.44
78	46.10	62.25	141	109.23	61.36	186	154.59	60.41
80	48.09	62.23	142	110.24	61.34	187	155.60	60.39
82	50.08	62.21	143	111.25	61.32	188	156.61	60.37
84	52.07	62.19	144	112.26	61.30	189	157.62	60.34
86	54.06	62.17	145	113.26	61.28	190	158.62	60.32
88	56.05	62.15	146	114.27	61.26	191	159.63	60.29
90	58.04	62.13	147	115.28	61.24	192	160.63	60.27
92	60.03	62.11	148	116.29	61.22	193	161.64	60.25
94	62.02	62.09	149	117.30	61.20	194	162.65	60.22
96	64.01	62.07	150	118.30	61.18	195	163.66	60.20
98	66.01	62.05	151	119.31	61.16	196	164.66	60.17
100	68.01	62.02	152	120.32	61.14	197	165.67	60.15
102	70.00	62.00	153	121.33	61.12	198	166.68	60.12
104	72.00	61.97	154	122.34	61.10	199	167.69	60.10
106	74.00	61.95	155	123.34	61.08	200	168.70	60.07
108	76.00	61.92	156	124.35	61.06	201	169.70	60.05
110	78.00	61.89	157	125.36	61.04	202	170.71	60.02
112	80.00	61.86	158	126.37	61.02	203	171.72	60.00
113	81.01	61.84	159	127.38	61.00	204	172.73	59.97
114	82.02	61.83	160	128.38	60.98	205	173.74	59.95
115	83.02	61.82	161	129.39	60.96	206	174.74	59.92
116	84.03	61.80	162	130.40	60.94	207	175.75	59.89
117	85.04	61.78	163	131.41	60.92	208	176.76	59.87
118	86.05	61.77	164	132.42	60.90	209	177.77	59.84
119	87.06	61.75	165	133.42	60.87	210	178.78	59.82
120	88.06	61.74	166	134.43	60.85	211	179.78	59.79
121	89.07	61.72	167	135.44	60.83	212	180.79	59.76
122	90.08	61.70						

required to make one pound of steam is found by subtracting the "*heat in liquid*" at 100° F., found in Table II, from the "*total heat*" at 70 pounds gauge pressure, found in column 3 of Table I. In this case 1178.2–68.01=1110.19 heat units; hence, 1110.19÷965.8=1.1495, which is the factor of evaporation required.

The table of "*Factors of Evaporation*" is used to reduce the actual amount of water evaporated to the equivalent "*from and at 212°.*" It is desirable to do this for the purpose of comparing results obtained under different conditions of steam pressure and feed water temperature. If, for example, 15,000 pounds of water were evaporated at 70 pounds gauge pressure, from feed water 100° temperature, the equivalent "*from and at 212°*" would be found by multiplying 15,000 by the "*factor of evaporation*," 1.1495, giving 17,241 pounds.

TABLE III.

Table of Factors of Evaporation.

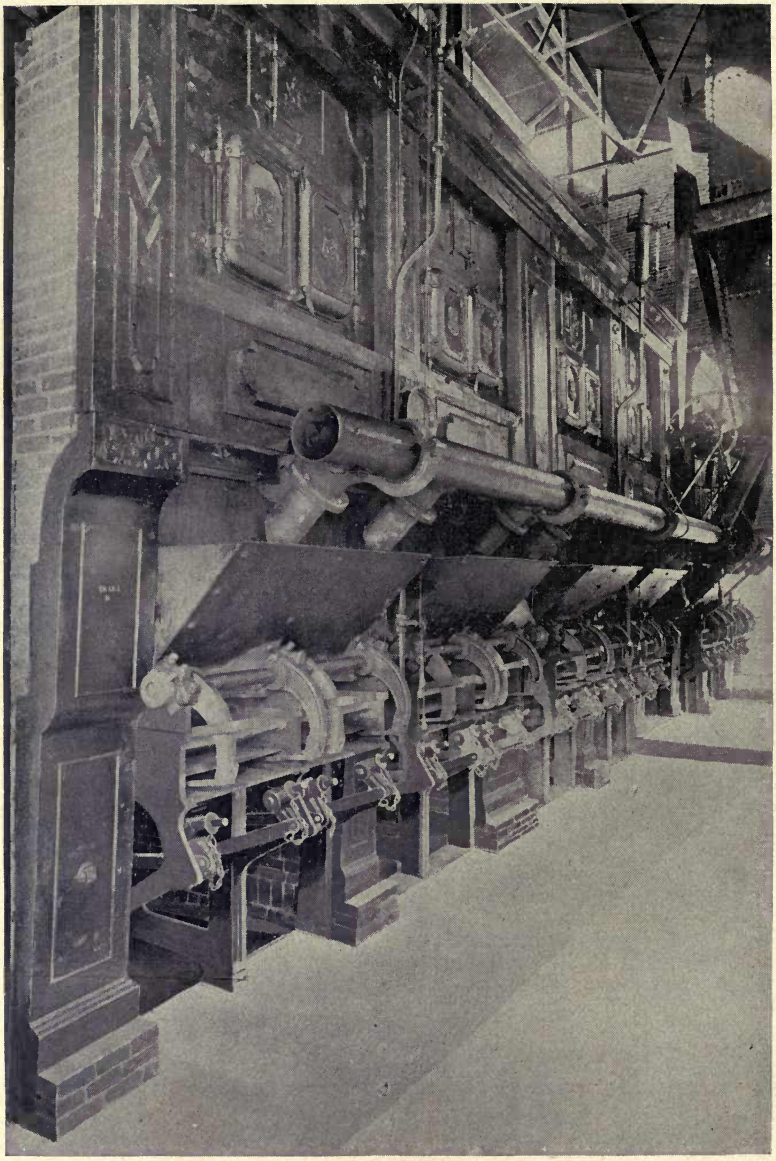
Temperature Feed-Water. Fahrenheit.	PRESSURE IN POUNDS PER SQUARE INCH ABOVE THE ATMOSPHERE.										Temperature Feed-Water. Fahrenheit.
	0.	5.	15.	25.	35.	45.	55.	65.	75.	85.	
Degr's											Degr's
32	1.187	1.192	1.199	1.204	1.209	1.212	1.216	1.218	1.221	1.223	32
35	1.184	1.189	1.196	1.201	1.206	1.209	1.213	1.215	1.218	1.220	35
40	1.179	1.184	1.191	1.196	1.201	1.204	1.208	1.219	1.213	1.215	40
45	1.173	1.178	1.185	1.190	1.195	1.198	1.202	1.204	1.207	1.209	45
50	1.168	1.173	1.180	1.185	1.190	1.193	1.197	1.199	1.202	1.204	50
55	1.163	1.168	1.175	1.180	1.185	1.188	1.192	1.194	1.197	1.199	55
60	1.158	1.163	1.170	1.175	1.180	1.183	1.187	1.189	1.192	1.194	60
65	1.153	1.158	1.165	1.170	1.175	1.178	1.182	1.184	1.187	1.189	65
70	1.148	1.153	1.160	1.165	1.170	1.173	1.177	1.179	1.182	1.184	70
75	1.143	1.148	1.155	1.160	1.165	1.168	1.172	1.174	1.177	1.179	75
80	1.137	1.142	1.149	1.154	1.159	1.162	1.166	1.168	1.171	1.173	80
85	1.132	1.137	1.144	1.149	1.154	1.157	1.161	1.163	1.166	1.168	85
90	1.127	1.132	1.139	1.144	1.149	1.152	1.156	1.158	1.161	1.163	90
95	1.122	1.127	1.134	1.139	1.144	1.147	1.151	1.153	1.156	1.158	95
100	1.117	1.122	1.129	1.134	1.139	1.142	1.146	1.148	1.151	1.153	100
105	1.111	1.116	1.123	1.128	1.133	1.136	1.140	1.142	1.145	1.147	105
110	1.106	1.111	1.118	1.123	1.128	1.131	1.135	1.137	1.140	1.142	110
115	1.101	1.106	1.113	1.118	1.123	1.126	1.130	1.132	1.135	1.137	115
120	1.096	1.101	1.108	1.113	1.118	1.121	1.125	1.127	1.130	1.132	120
125	1.091	1.096	1.103	1.108	1.113	1.116	1.120	1.122	1.125	1.127	125
130	1.085	1.090	1.097	1.102	1.107	1.110	1.114	1.116	1.119	1.121	130
135	1.080	1.085	1.092	1.097	1.102	1.105	1.109	1.111	1.114	1.116	135
140	1.075	1.080	1.087	1.092	1.097	1.100	1.104	1.106	1.109	1.111	140
145	1.070	1.075	1.082	1.087	1.092	1.095	1.099	1.101	1.104	1.106	145
150	1.065	1.070	1.077	1.082	1.087	1.090	1.094	1.096	1.099	1.101	150
155	1.059	1.064	1.071	1.076	1.081	1.084	1.088	1.090	1.094	1.095	155
160	1.054	1.059	1.066	1.071	1.076	1.079	1.083	1.085	1.088	1.090	160
165	1.049	1.054	1.061	1.066	1.071	1.074	1.078	1.080	1.083	1.085	165
170	1.044	1.049	1.056	1.061	1.066	1.069	1.073	1.075	1.078	1.080	170
175	1.039	1.044	1.051	1.056	1.061	1.064	1.068	1.070	1.073	1.075	175
180	1.033	1.038	1.045	1.050	1.055	1.058	1.062	1.064	1.067	1.069	180
185	1.028	1.033	1.040	1.045	1.050	1.053	1.057	1.059	1.062	1.064	185
190	1.023	1.028	1.035	1.040	1.045	1.048	1.052	1.054	1.057	1.059	190
195	1.018	1.023	1.030	1.035	1.040	1.043	1.047	1.049	1.052	1.054	195
200	1.013	1.018	1.025	1.030	1.035	1.038	1.042	1.044	1.047	1.049	200
205	1.007	1.012	1.019	1.024	1.029	1.032	1.036	1.038	1.041	1.043	205
210	1.002	1.007	1.014	1.019	1.024	1.027	1.031	1.033	1.036	1.038	210
212	1.000	1.005	1.012	1.017	1.022	1.025	1.029	1.031	1.034	1.036	212

TABLE III.—Continued.

Table of Factors of Evaporation.

Temperature Feed-Water. Fahrenheit.	PRESSURE IN POUNDS PER SQUARE INCH ABOVE THE ATMOSPHERE.										Temperature Feed-Water. Fahrenheit.
	95.	105.	115.	125.	135.	145.	155.	165.	175.	185.	
Degr's											Degr's
32	1.226	1.228	1.230	1.231	1.233	1.235	1.236	1.238	1.239	1.240	32
35	1.223	1.225	1.227	1.228	1.230	1.232	1.233	1.235	1.236	1.237	35
40	1.218	1.220	1.222	1.223	1.225	1.227	1.228	1.230	1.231	1.232	40
45	1.212	1.214	1.216	1.217	1.219	1.221	1.222	1.224	1.225	1.226	45
50	1.207	1.209	1.211	1.212	1.214	1.216	1.217	1.219	1.220	1.221	50
55	1.202	1.204	1.206	1.207	1.209	1.211	1.212	1.214	1.215	1.216	55
60	1.197	1.199	1.201	1.202	1.204	1.206	1.207	1.209	1.210	1.211	60
65	1.192	1.194	1.196	1.197	1.199	1.201	1.202	1.204	1.205	1.206	65
70	1.187	1.189	1.191	1.192	1.194	1.196	1.197	1.199	1.200	1.201	70
75	1.182	1.184	1.186	1.187	1.189	1.191	1.192	1.194	1.195	1.196	75
80	1.176	1.178	1.180	1.181	1.183	1.185	1.186	1.188	1.189	1.190	80
85	1.171	1.173	1.175	1.176	1.178	1.180	1.181	1.183	1.184	1.185	85
90	1.166	1.168	1.170	1.171	1.173	1.175	1.176	1.178	1.179	1.180	90
95	1.161	1.163	1.165	1.166	1.168	1.170	1.171	1.173	1.174	1.175	95
100	1.156	1.158	1.160	1.161	1.163	1.165	1.166	1.168	1.169	1.170	100
105	1.150	1.152	1.154	1.155	1.157	1.159	1.160	1.162	1.163	1.164	105
110	1.145	1.147	1.149	1.150	1.152	1.154	1.155	1.157	1.158	1.159	110
115	1.140	1.142	1.144	1.145	1.147	1.149	1.150	1.152	1.153	1.154	115
120	1.135	1.137	1.139	1.140	1.142	1.144	1.145	1.147	1.148	1.149	120
125	1.130	1.132	1.134	1.135	1.137	1.139	1.140	1.142	1.143	1.144	125
130	1.124	1.126	1.128	1.129	1.131	1.133	1.134	1.136	1.137	1.138	130
135	1.119	1.121	1.123	1.124	1.126	1.128	1.129	1.131	1.132	1.133	135
140	1.114	1.116	1.118	1.119	1.121	1.123	1.124	1.126	1.127	1.128	140
145	1.109	1.111	1.113	1.114	1.116	1.118	1.119	1.121	1.122	1.123	145
150	1.104	1.106	1.108	1.109	1.111	1.113	1.114	1.116	1.117	1.118	150
155	1.098	1.100	1.102	1.103	1.105	1.107	1.108	1.110	1.111	1.112	155
160	1.093	1.095	1.097	1.098	1.100	1.102	1.103	1.105	1.106	1.107	160
165	1.088	1.090	1.092	1.093	1.095	1.097	1.098	1.100	1.101	1.102	165
170	1.083	1.085	1.087	1.088	1.090	1.092	1.093	1.095	1.096	1.097	170
175	1.078	1.080	1.082	1.083	1.085	1.087	1.088	1.090	1.091	1.092	175
180	1.072	1.074	1.076	1.077	1.079	1.081	1.082	1.084	1.085	1.086	180
185	1.067	1.069	1.071	1.073	1.074	1.076	1.077	1.079	1.080	1.081	185
190	1.062	1.064	1.066	1.067	1.069	1.071	1.072	1.074	1.075	1.076	190
195	1.057	1.059	1.061	1.062	1.064	1.066	1.066	1.069	1.070	1.071	195
200	1.052	1.054	1.056	1.057	1.059	1.061	1.062	1.064	1.065	1.066	200
205	1.046	1.048	1.050	1.051	1.053	1.055	1.056	1.058	1.059	1.060	205
210	1.041	1.043	1.045	1.046	1.048	1.050	1.051	1.053	1.054	1.055	210
212	1.039	1.041	1.043	1.044	1.046	1.048	1.049	1.051	1.052	1.053	212

. T. McCROSSON
MONTGOMERY ST.
AN FRANCISCO, CAL.
IFIC COAST AGENT.



1000 H. P. STIRLING BOILERS EQUIPPED WITH MEISSNER STOKERS, AT STANDARD OIL CO. No. 1 PLANT, CLEVELAND, OHIO.

HORSE POWER OF BOILERS.

A HORSE POWER is primarily a measure of the amount of work done in a specified time. It is equal to the work done in lifting 33,000 pounds 1 foot high in one minute, or 33 pounds 1,000 feet high, or 1,000 pounds 33 feet high in one minute. The work which a steam engine can do in a given time is thus measured in horse power, usually called "net horse power" or "brake horse power." But the work which must be done by the steam in the engine cylinder is always greater than the work which the engine can deliver, because a portion is always consumed by the friction of the engine. In other words, the "indicated horse power," i. e., the horse power delivered by the steam to the piston, as measured by the steam engine indicator, is always greater than the net horse power. Now, in every steam engine working under steady conditions, a certain number of pounds of steam is required per hour to give an "indicated horse power." This amount differs greatly in different engines, and under different loads in the same engine; a good triple expansion condensing engine will give an "indicated horse power" upon 14 pounds of steam per hour, while an old style slide valve engine will require from 60 to 80 pounds of steam per hour for an "indicated horse power." It is evident, therefore, that the amount of steam per hour required to produce an "indicated horse power" is a variable quantity depending upon the engine.

In order to provide for a uniform standard, the judges at the Centennial Exposition fixed upon a value of thirty pounds of steam per "indicated horse power" as a suitable average, and defined a boiler horse power as the evaporation of thirty pounds of water per hour into dry steam, from feed

water at a temperature of 100°, to a pressure of 70 pounds. A boiler, then, that will evaporate 3,000 pounds of water per hour from feed at 100° into steam at 70 pounds pressure is rated at 100 horse power. The "factor of evaporation from and at 212°" under these conditions we have just found to be 1.1495, and, as we have 30 pounds of water per horse power, 30×1.1495=34.485, which is the amount of water which would be evaporated "from and at 212°" by the heat required to produce one Centennial standard horse power. Hence, the rule:

To determine the Centennial standard horse power developed by a boiler: Divide the number of pounds of water evaporated from and at 212° by 34.485. And, further,—

To determine the standard horse power developed when pressure of steam, temperature of feed, and pounds of water evaporated are given: Multiply the pounds of water actually evaporated by the proper factor in Table III (which will give the equivalent evaporation from and at 212°), and divide by 34.485.

HEATING OF FEED WATER.

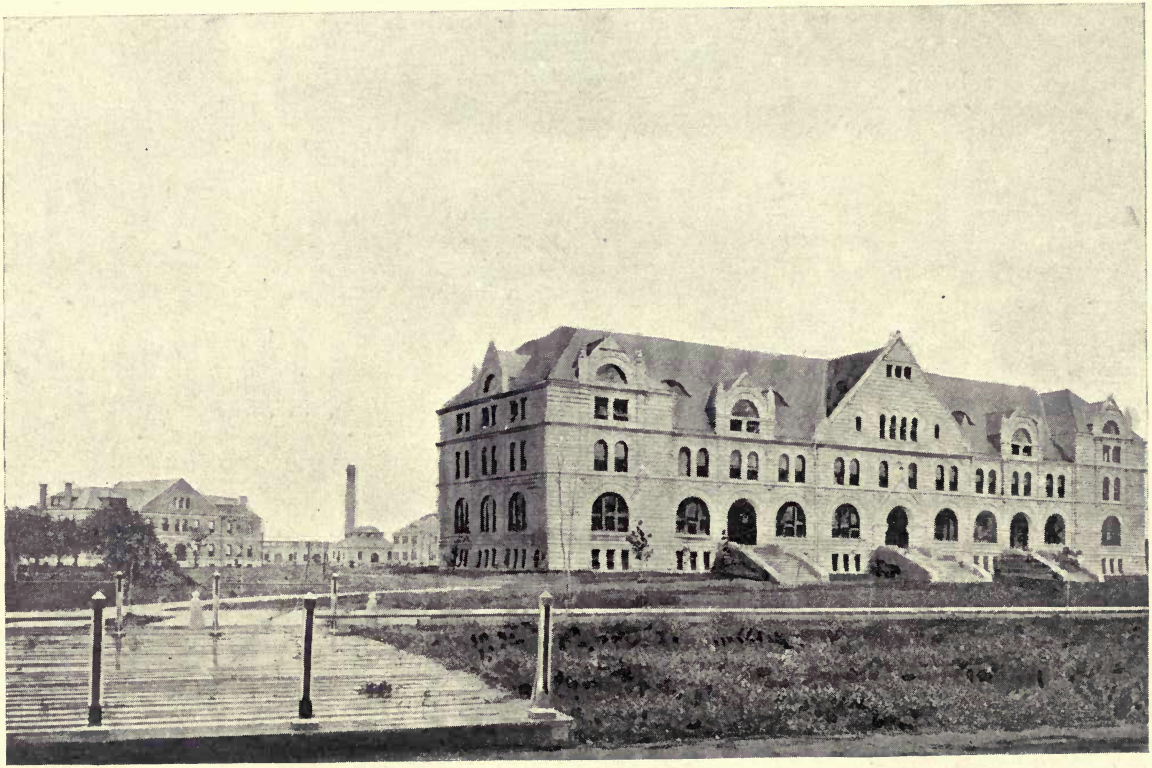
A DUE regard for economy in the production and saving of power, requires that that contained in the heat of exhaust steam be applied to some useful purpose, and as a rule it is best utilized in raising the temperature of the feed water to the highest point of which it is economically capable. To effect this the heater is used, and when in addition to this duty it is possible by its use to eliminate most of the impurities contained in the water, its great value to an economical steam plant will be acknowledged and appreciated.

The great variety of heaters upon the market may all be classed under three heads: closed coil, open, and the tubular type. The first is a heater simply,—and the last two in addition, separate more or less perfectly, according to the design, such impurities in the feed water as the heat contained in the exhaust steam will cause to rise to the surface or be deposited by precipitation. In either case, if provision is made for immediate removal of the deposits, the function of the heater, wherein only exhaust steam is used, will be accomplished.

The heat of escaping gases as they leave the boiler is also frequently utilized in raising the temperature of the feed water, and a machine known as an Economizer is used for this purpose. There are a number on the market, and performing very excellent service.

The following table gives the percentage of gain or loss of power or fuel by different temperatures of the feed water heated or cooled. The first column contains the temperature of the feed water at which it enters the boiler, and the top line contains the temperature from which the water is heated or cooled.

SAN FRANCISCO, CAL.
PACIFIC COAST AGENT.



TULARE UNIVERSITY, NEW ORLEANS, LA. HEAT, LIGHT AND POWER FURNISHED BY STIRLING BOILERS.

Suppose water to enter the feed-pump at 32° and to be heated to 160°, there will be 13 per cent gained in power and fuel. When water enters the feed-pump at 60° and is heated to 150°, there will be 10 per cent gained.

Suppose the water in the heater is 180°, which, when passing in a long pipe to the steam-boiler, is reduced to 150°, the loss will then be 3 per cent. The sign + for gain and — for loss:

PERCENTAGE OF POWER OR FUEL GAINED BY HEATING THE FEED-WATER.—NYSTROM.

Temperature Enter'g Boiler.	Temperature from which the Feed-Water is Heated or Cooled.											
	32	40	50	60	70	80	100	120	140	160	180	200
32	0.0	— 1.	— 1.5	— 2.	— 3.4	— 4.4	— 6.5	— 9.	—11.	—13.	—16.	—19.
40	+ 1.	0.0	— 0.5	— 1.	— 2.4	— 3.4	— 5.5	— 8.	—10.	—12.	—15.	—18.
50	+ 1.5	+ 0.5	0.0	— 0.5	— 2.	— 3.	— 4.	— 7.	— 9.	—11.	—14.	—17.
60	+ 2.	+ 1.	+ 0.5	0.0	— 1.4	— 2.4	— 3.5	— 6.	— 8.	—10.	—14.	—16.
70	+ 3.4	+ 2.4	+ 2.	+ 1.4	0.0	— 1.	— 3.	— 5.	— 7.	— 9.	—13.	—15.
80	+ 4.4	+ 3.4	+ 3.	+ 2.4	+ 1.	0.0	— 2.	— 4.	— 6.	— 8.	—12.	—14.
90	+ 5.4	+ 4.4	+ 4.	+ 3.4	+ 2.	+ 1.	— 1.	— 3.	— 5.	— 7.	—11.	—13.
100	+ 6.5	+ 5.5	+ 5.	+ 4.4	+ 3.	+ 2.	0.0	— 2.	— 4.	— 6.	— 9.5	—12.
110	+ 7.6	+ 6.6	+ 6.	+ 5.6	+ 4.2	+ 3.2	+ 1.	— 1.	— 3.	— 5.	— 8.	—11.
120	+ 8.7	+ 7.7	+ 7.	+ 6.7	+ 5.3	+ 4.3	+ 2.2	0.0	— 2.	— 4.	— 7.	—10.
130	+ 9.8	+ 8.8	+ 8.3	+ 7.8	+ 6.4	+ 5.4	+ 3.3	+ 1.	— 1.	— 3.	— 6.	— 9.
140	+11.	+10.	+ 9.	+ 9.	+ 8.	+ 7.	+ 4.5	+ 2.	0.0	— 2.	— 5.	— 8.
150	+12.	+11.	+10.	+10.	+ 9.	+ 8.	+ 5.5	+ 3.	+ 1.	— 1.	— 3.	— 7.
160	+13.	+12.	+11.	+11.	+10.	+ 9.	+ 6.5	+ 4.	+ 2.	0.0	— 2.	— 6.
170	+15.	+14.	+12.	+12.	+12.	+11.	+ 8.	+ 6.	+ 4.	+ 2.	— 1.	— 4.
180	+16.	+15.	+14.	+14.	+13.	+12.	+ 9.	+ 7.	+ 5.	+ 3.	0.0	— 3.
190	+17.	+16.	+15.	+15.	+14.	+13.	+10.	+ 8.	+ 6.	+ 4.	+ 1.	— 2.
200	+19.	+18.	+17	+17.	+16.	+15.	+12.	+10.	+ 8.	+ 6.	+ 3.	0.0
212	+20.	+19.	+18.	+18.	+17.	+16.	+14.	+11.	+ 9.	+ 7.	+ 4.	+ 1.

EFFICIENCY OF COALS.

COAL, as a fuel, is rated according to the quantities and calorific value of the combustible elements it contains. The most important of these are carbon and hydrogen; the combustion of one pound of hydrogen producing 62,000 B. T. U., and of one pound of carbon, 14,500 B. T. U. Hence, although several coals may have the same percentage of combustible and ash, it does not follow that their calorific value will be identical, for this depends upon the amount of hydrogen and carbon they contain.

The value of fuel may be determined by chemical analysis, by which the proportion of the elements that it contains is found, and by calorimetric test, although the latter is considered the more reliable method of the two.

In practice, no fuel gives its full theoretical evaporation value, owing, first, to the losses that result from radiation and conduction of heat from the boiler setting, which in some cases have been found as high as 24 per cent; second, to the carelessness, or ignorance, of the fireman in improperly firing; third, to the frequent admission of cold air into the furnace, either through the firing doors or through cracks in the setting; fourth, to errors in the design and construction of the boiler itself. An efficiency of 80 per cent is seldom obtained, and only in the best boilers, whilst the average is about 65 per cent,—the better the boiler the higher the efficiency.

The following table, giving the chemical analyses and calculated calorific values of coals, has been prepared by experts employed by the Stirling Company, from the reports of the "Mineralogical Resources of the United States," and from similar publications by coal-producing States:

AMERICAN COALS.

LOCALITY.	Analysis per cent of Weight.					Fuel Value per Pound of Coal.	
	Water.	Volatile Matter.	Fixed Carbon	Ash.	Sulphur.	Calculated B. T. U.	Theoretical Evaporation in lbs. from and at 212° F.
ALABAMA.							
Coalburg, Jefferson Co	0.935	30.745	65.075	3.014	1.203	14,513	15.02
Warrior, " "	1.17	33.88	63.03	1.92	1.20	14,550	15.06
Brierfield, Bibb Co	.....	41.04	55.76	3.20	1.01	14,620	15.13
Corona, Walker Co	0.83	41.12	50.69	7.36	.....	13,851	14.34
Patton Junc., Walker Co	1.66	22.12	68.34	6.00	1.85	13,410	13.88
ARKANSAS.							
Huntington Slope, Sebastian Co	0.928	15.546	77.538	4.845	1.143	13,813	14.30
Quito, Polk Co	0.980	12.20	76.817	8.174	1.829	13,117	13.27
Felker Slope, Franklin Co	1.128	13.211	81.277	3.22	1.164	13,927	14.41
Philpott Shaft, Johnson Co	0.869	14.133	80.915	3.09	0.993	14,020	14.51
Coal Hill, " "	1.017	10.841	76.119	8.351	3.672	13,053	13.51
CALIFORNIA.							
Livermore, Alameda Co	18.08	39.30	35.61	7.01	.....	11,438	11.84
COLORADO.							
Boulder Co	12.01	35.19	46.24	6.56	.....	12,271	12.70
Fremont Co	3.93	42.43	47.16	6.48	.....	13,555	14.03
" "	.....	42.40	53.72	3.20	.....	14,559	15.07
Las Animas Co	1.26	36.40	53.10	0.924	.....	13,434	13.94
ILLINOIS.							
Mount Carbon, Jackson Co	6.37	31.93	59.13	1.81	0.76	13,673	14.15
Carbondale, " "	6.36	26.40	59.84	7.40	.....	12,838	13.29
Oglesby, La Salle Co	12.12	30.84	49.32	7.72	.....	12,013	12.44
Lombardville, Stark Co	9.42	31.38	51.74	7.46	.....	12,453	12.89
Bloomington, McLean Co	7.90	34.02	53.12	4.96	.....	13,100	13.56
Blair Bluff, Henry Co	12.60	28.96	48.54	9.90	.....	11,578	11.99
Kewanee, " "	15.60	27.60	49.66	7.14	.....	11,552	11.96
Barclay, Sangamon Co	10.80	27.32	44.78	17.10	.....	10,699	11.08
Catlin, Vermillion Co	7.80	31.08	48.42	12.70	.....	11,871	12.29
Grape Creek, Vermillion Co	9.74	28.34	51.32	10.60	.....	11,876	12.29
Duquoin, Perry Co	8.86	23.54	60.60	7.00	.....	12,697	13.14
Elmwood, Peoria Co	7.60	27.60	55.30	9.50	.....	12,348	12.78
Farmington, Fulton Co	8.52	29.28	50.48	11.72	.....	11,683	12.09
Lincoln, Logan Co	10.92	27.60	46.64	14.84	.....	11,036	11.42
INDIAN TERRITORY.							
McAlister, Tobocksey Co	2.10	29.71	62.67	5.52	.....	13,796	14.27
Lehigh, Atoka Co	4.61	39.16	45.74	10.49	.....	12,791	13.24
INDIANA.							
Fountain Co	5.0	36.0	54.5	4.5	.....	13,621	14.10

AMERICAN COALS—Continued.

LOCALITY.	Analysis per cent of Weight.					Fuel Value per Pound of Coal.	
	Water.	Volatile Matter.	Fixed Carbon	Ash.	Sulphur.	Calculated B. T. U.	Theoretical Evaporation in lbs. from and at 212° F.
INDIANA—Continued.							
Vanderburg Co	3.5	42.0	48.5	6.0	.....	13,690	14.17
Warwick Co	3.5	41.5	49.5	5.5	.....	13,761	14.24
Posey Co	4.0	39.5	55.0	5.5	.....	13,660	14.14
Sullivan Co	3.5	40.0	55.0	1.5	.....	14,362	14.87
Daviess Co	5.5	36.0	53.5	5.0	.....	13,471	13.95
Vermillion Co	5.5	44.0	46.0	4.5	.....	13,661	14.14
Parke Co	4.0	46.0	46.5	3.5	.....	14,062	14.56
Montgomery Co	3.0	41.5	52.0	3.5	.....	14,146	14.64
Clay Co	3.5	32.5	61.5	2.5	.....	13,898	14.39
Owen Co	2.0	38.5	57.5	2.0	.....	14,481	14.99
Greene Co	7.0	29.5	63.0	0.05	.....	13,861	14.35
IOWA.							
Albia, Monroe Co	5.16	40.21	45.88	8.75	.....	12,997	13.45
Oskaloosa, Marion Co	5.73	46.54	45.60	2.13	.....	14,040	14.53
Ottumwa, Wapello Co	6.50	41.35	48.25	3.90	.....	13,571	14.05
KANSAS.							
Cherokee Co	1.94	36.77	52.45	8.84	.....	13,403	13.87
KENTUCKY.							
Peach Orchard, Lawrence Co	3.24	36.56	49.24	11.56	1.793	12,875	13.33
Manchester, Clay Co	1.20	38.10	60.70	5.80	1.793	14,845	15.36
Hawesville, Hancock Co	3.30	39.00	50.50	7.20	3.373	12,490	12.93
Clifton, Hopkins Co	.....	33.32	47.45	16.02	3.21	12,054	12.48
Kensee, Whitley Co	1.90	32.86	63.10	2.14	0.70	14,396	14.90
MARYLAND.							
Cumberland	1.23	15.47	73.51	9.09	0.70	13,067	13.53
MISSOURI.							
Rich Hill, Bates Co	2.54	42.62	41.14	13.70	.....	12,641	13.08
MONTANA.							
Sand Coulle, Cascade Co	3.01	30.23	59.71	7.05	.....	13,504	13.98
NEW MEXICO.							
Ranton, Colfax Co	3.10	35.00	51.50	10.40	.....	12,966	13.42
OHIO.							
Buchtel, Athens Co	5.10	36.97	49.68	8.25	2.41	13,037	13.50
Bellaire, Belmont Co	1.53	42.29	47.57	8.61	4.47	13,575	14.05
Salineville, Columbiana Co	2.32	39.08	52.78	5.82	2.58	13,849	14.34
Cambridge, Guernsey Co	5.32	37.46	53.29	3.93	1.38	13,687	14.17

AMERICAN COALS—Continued.

LOCALITY.	Analysis per cent of Weight.					Fuel Value per Pound of Coal.	
	Water.	Volatile Matter.	Fixed Carbon	Ash.	Sulphur.	Calculated B. T. U.	Theoretical Evaporation in lbs. from and at 212° F.
OHIO—Continued.							
Walnut Creek, Holmes Co.	4.49	42.50	47.27	5.74	3.41	13,594	14.07
Brilliant, Jefferson Co.	1.85	37.82	55.62	4.71	1.32	14,072	14.57
Morgan, Morgan Co.	4.20	38.65	43.83	13.32	5.37	12,403	12.84
Brookfield, Noble Co.	3.27	40.23	42.72	11.78	5 90	12,800	13.25
New Straitsville, Perry Co.	7.09	36.61	52.00	4.30	1.19	13,357	13.51
Liberty, Trumbull Co.	5.91	35.01	55.70	3.38	0.76	11,983	12.40
Pike, Stark Co.	2.85	39.00	46.69	11.46	3.14	12,893	13.34
OREGON.							
Coos Co.	15.45	41.45	34.95	8.05	2.53	11,628	12.04
PENNSYLVANIA.							
Hillsboro, Washington Co.	0.77	36.115	48.554	12.415	2.146	12,695	13.14
Monongahela, " "	1.18	35.83	58.154	4.075	0.761	14,130	14.63
Franklin, Greene Co.	1.265	34.685	49.59	13.19	1.27	12,309	12.74
Summer Hill, Cambria Co.	0.820	19.155	70.175	9.405	0.445	13,164	13.62
Keystone, Somerset Co.	1.29	20.865	67.201	8.805	1.839	13,012	13.47
Latrobe, Westmoreland Co.	1.59	30.945	63.489	3.18	0.796	14,135	14.63
Irwin, " "	1.78	35.36	59.29	2.89	0.68	14,232	14.73
West Lebanon, Indiana Co.	1.04	36.94	50.85	9.705	1.465	13,189	13.65
Connellville, Fayette Co.	1.26	30.107	59.616	8.233	0.784	13,390	13.86
Nicholson, " "	1.06	34.805	53.538	8.165	2.432	13,254	13.72
Perry, Lawrence Co.	1.94	39.265	55.828	2.24	0.727	14,358	14.86
Bennington, Blair Co.	0.98	26.40	65.586	4.78	2.274	14,704	15.22
Centre, Butler Co.	2.11	37.57	51.248	7.178	1.894	13,372	13.84
Osceola, Clearfield Co.	1.24	24.45	67.045	5.945	1.32	13,589	14.07
Carbon, Huntingdon Co.	0.45	16.21	70.601	8.569	4.17	13,770	14.25
Antrim, Tioga Co.	1.46	21.60	65.12	9.00	2.82	12,825	13.27
Gillesville, McKean Co.	0.67	36.065	48.417	13.79	1.058	12,653	13.09
Bernice, Sullivan Co.	1.295	8.10	83.344	6.23	1.031	13,350	13.82
Schuylkill Co.	2.98	3.38	87.127	5.856	0.657	13,153	13.61
Cameron, Northumberland Co.	1.815	6.180	86.748	4.502	0.755	13,557	14.04
RHODE ISLAND.							
Portsmouth	.....	10.0	84.50	5.50	.....	13,829	14.31
TENNESSEE.							
Coal Creek, Anderson Co.	.....	34.20	58.80	6.93	0.79	13,936	14.43
Soddy, Hamilton Co.	.....	28.90	56.89	14.21	.....	12,740	13.19
Newcombe, Campbell Co.	.....	33.77	60.64	3.59	1.10	14,168	14.67
TEXAS.							
Eagle Mine	3.54	30.84	50.69	14.93	.....	12,140	12.57

SAN FRANCISCO, CAL.
PACIFIC COAST AGENT.

THE ARMOUR INSTITUTE, CHICAGO, CONTAINING 800 H. P. STIRLING BOILERS.

AMERICAN COALS—CONTINUED.

LOCALITY.	Analysis per cent of Weight.					Fuel Value per Pound of Coal.	
	Water.	Volatile Matter.	Fixed Carbon	Ash.	Sulphur.	Calculated B. T. U.	Theoretical Evaporation in lbs. from and at 212° F.
TEXAS—CONTINUED.							
Sabinas Mine	0.83	29.35	50.18	19.63	.....	11,782	12.20
Cedral Mine	0.45	21.60	45.70	29.10	.....	9,800	10.14
UTAH.							
Scofield, Emery Co	.....	39.85	47.30	5.55	7.30	13,178	13.64
Coalville, Summit Co	.....	38.90	56.37	4.30	10.32	12,903	13.35
VIRGINIA.							
Pocahontas, Wise Co	6.940	18.832	74.066	5.647	0.761	13,718	14.20
Clover Hill	1.339	30.984	56.831	10.132	0.514	13,103	13.56
Carbon Hill	0.40	18.60	71.00	10.00	.....	13,192	13.65
Coalbrookdale	.....	24.00	70.80	5.20	.....	14,068	14.50
WASHINGTON.							
Wilkeson, Pierce Co	1.10	35.10	54.50	9.30	.....	13,429	13.90
Roslyn, Kittitass Co	2.42	27.37	56.69	13.36	0.16	12,475	12.91
Newcastle	11.70	35.50	46.00	6.04	0.04	12,290	12.72
Franklin	3.33	33.92	57.68	5.07	.....	13,746	14.23
WEST VIRGINIA.							
Elmo, Fayette Co	1.05	23.62	72.67	2.20	0.76	14,314	14.81
New River, Fayette Co	0.67	26.64	70.66	1.53	0.50	14,509	15.02
Cedar Grove, Kanawha Co	2.10	34.08	60.67	2.50	0.65	12,233	12.66
WYOMING.							
Glenrock	10.20	34.40	51.11	5.29	.....	12,865	13.31
Dana, Carbon Co	11.30	42.01	39.69	7.00	.....	12,401	12.83
Rawlins	7.47	36.05	51.56	4.32	.....	13,204	13.66

SIZES OF CHIMNEYS WITH APPROPRIATE HORSE-POWER OF BOILERS.

Round Chimney, Diameter in Inches.	Square Chimney, Sides of Square.	Actual Area, Square Feet.	Effective Area, Square Feet.	HEIGHT OF CHIMNEYS AND COMMERCIAL HORSE-POWER.										
				50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.
18	16×16	1.77	0.97	23	25	27	.....	.....	.....	.....	.....	.....	.....	.....
21	19×19	2.41	1.47	35	38	41	.....	.....	.....	.....	.....	.....	.....	.....
24	22×22	3.14	2.08	49	54	58	62	.....	.....	.....	.....	.....	.....	.....
27	24×24	3.98	2.78	65	72	78	83	.....	.....	.....	.....	.....	.....	.....
30	27×27	4.91	3.58	84	92	100	107	113	.....	.....	.....	.....	.....	.....
33	30×30	5.94	4.48	.....	115	125	133	141	.....	.....	.....	.....	.....	.....
36	32×32	7.07	5.47	.....	141	152	163	173	182	.....	.....	.....	.....	.....
39	35×35	8.30	6.57	.....	.....	183	196	208	219	.....	.....	.....	.....	.....
42	38×38	9.62	7.76	.....	.....	216	231	245	258	271	.....	.....	.....	.....
48	43×43	12.57	10.44	.....	.....	.....	311	330	348	365	389	.....	.....	.....
54	48×48	15.90	13.51	.....	.....	.....	.....	427	449	472	503	551	.....	.....
60	54×54	19.64	16.98	.....	.....	.....	.....	536	565	593	632	692	748	.....
66	59×59	23.76	20.83	.....	.....	.....	.....	.....	694	728	776	849	918	981
72	64×64	28.27	25.08	.....	.....	.....	.....	.....	835	876	934	1023	1105	1181
78	70×70	33.18	29.73	.....	.....	.....	.....	.....	.....	1038	1107	1212	1310	1400
84	75×75	38.48	34.76	.....	.....	.....	.....	.....	.....	1214	1294	1418	1531	1637
90	80×80	44.18	40.19	.....	.....	.....	.....	.....	.....	.....	1496	1639	1770	1893
96	86×86	50.27	46.01	.....	.....	.....	.....	.....	.....	.....	.....	1876	2027	2167

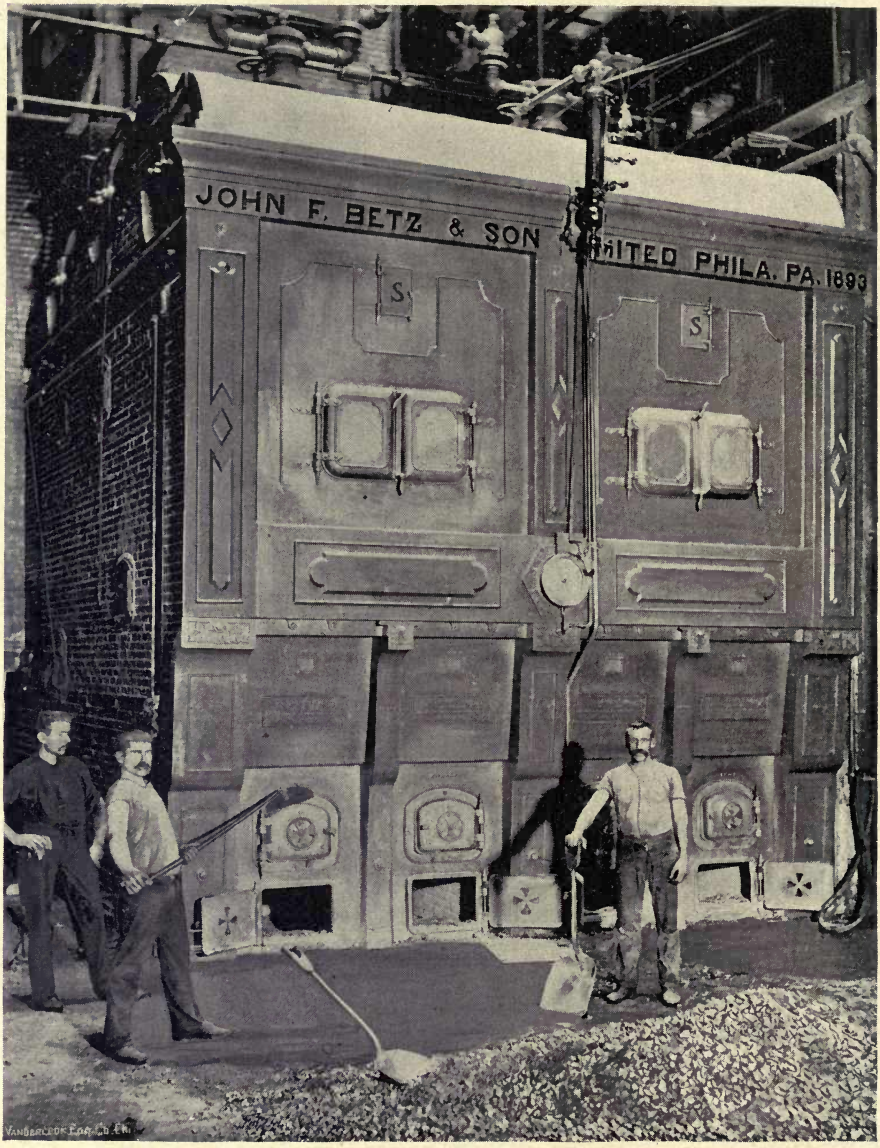
CHIMNEYS.

THE chimney or stack plays a most important part in the performance of a steam plant, in that it furnishes the air or oxygen, without which the combustion of the fuel would be incomplete. Opinions differ as to what are the right proportions of a chimney for a given number of horse power, for the reason that local conditions and the character of the fuel to be used enter very largely into the consideration of the subject. A wise rule, however, is to err on the side of over-capacity, as the fault of too much draught can be cured at the damper, while that of too little has no remedy.

The draught pressure is the difference in the weight of a column of outside air, and a column of the same area and height of the hot, and consequently lighter, air inside the chimney. By a simple method, this is measured in inches of water, shown by the difference of levels of water in the legs of a U shaped glass tube. A moderate draught will cause the levels to differ about a quarter of an inch; a fairly good draught, three-eighths to one-half inch; and a powerful draught, about three-quarters to one inch.

There are various rules and formulæ published for the proportion of chimneys. The table published herewith is taken from a paper read before the American Society of Mechanical Engineers, and is in general use.

. T. McCROSSON
MONTGOMERY ST.
AN FRANCISCO, CAL.
FIC COAST AGENT.



450 H. P. STIRLING BOILER AT THE JOHN F. BETZ BREWERY, PHILADELPHIA, PA.

UNITED STATES INSPECTION LAWS GOVERNING STEAM BOILERS.

A LAW regulating the strength and safety of steam boilers in the United States was passed by Congress in February, 1871, and went into force a year later, requiring all plates used in the construction of steam boilers to be stamped with the number of pounds equal to the breaking strength per square inch section of the iron; one-sixth ($\frac{1}{6}$) of the stamped number taken as the safety or working strength of the iron in the boiler.

The following quotations are copied from the rules prescribed for the boiler inspectors:

"When flat surfaces exist, the inspector must satisfy himself that the bracing, and also other parts of the boiler, are of equal strength with the shell, and he must also, after applying the hydrostatic test, thoroughly examine every part of the boiler to see that no weakness or fracture has been caused thereby. Inspectors must see that the flues are of proper thickness to avoid the danger of collapse. Flues of sixteen inches in diameter must not be less than one-quarter of an inch in thickness, and in proportion for flues of a greater or less diameter.

"Every iron or steel plate intended for the construction of boilers to be used on steam vessels shall be stamped by the manufacturers in the following manner, viz.: At the diagonal corners, at a distance of about four inches from the edges, and also at or near the center of each plate, with the name of the manufacturer, the place where manufactured, and the number of pounds tensile strain it will bear to the sectional square inch.

"The rule for proportioning the strength of boilers to the steam pressure is as follows:

"*Rule.*—Multiply one-sixth ($\frac{1}{6}$) of the lowest tensile strength found stamped on any plate in the cylindrical shell by the thickness expressed in parts of an inch of the thinnest plate in the same cylindrical shell, and divide the product by the radius or half the diameter of the shell expressed in inches, and the quotient will be the steam pressure in pounds per square inch, allowable in single-riveted boilers, to which add twenty per centum for double-riveting."

Example.—What pressure should a boiler be allowed to carry that is sixty inches in diameter, and made of plates $\frac{3}{8}$ inches thick, having a tensile strength of 60,000 pounds?

$$\frac{1}{6}\times 60{,}000\times\frac{3}{8}\div 30=125 \text{ lbs.}$$

pressure if single-riveted, or $125+\frac{1}{5}\times 125=150$ lbs. pressure if double-riveted.

From the foregoing the following rules are deduced: First.—Given the tensile strength, thickness of plate, and safety pressure to be carried, to find the diameter of boiler.

Rule.—Multiply one-sixth of the tensile strength by the thickness of plate expressed in parts of an inch, and divide the product by the safety steam pressure; the quotient will be the radius or half the diameter of boiler, to which add one-fifth for double-riveting.

Example.—What will be the diameter of a boiler constructed of plate having a tensile strength of 60,000 pounds, $\frac{3}{8}$ or .375 inches thick, to carry a safety steam pressure of 150 pounds?

$$\frac{1}{6}\times 60{,}000\times .375\div 150\times 2=50 \text{ inches,}$$

the proper diameter of the boiler single-riveted, or $50+10=60$ inches diameter if double-riveted.

Second.—Given the diameter of boiler, safety steam pressure and tensile strength, to find the proper thickness of iron.

Rule.—Multiply the radius by safety steam pressure, and divide the product by one-sixth of the tensile strength; the

quotient will be the proper thickness of plate expressed in decimal parts of an inch, if to be single-riveted, less one-sixth thereof if double-riveted.

Example.—What thickness of plate, having a tensile strength of 60,000 pounds, should be used in a boiler 60 inches in diameter? $30\times150\div16\times60,000=.45$ inches thick if single-riveted, or $.45-\frac{1}{6}\times.45=.375$ inches thick if double-riveted.

Third.—Given the diameter, safety pressure and thickness of plate, to find the proper tensile strength.

Rule.—Multiply the radius by safety steam pressure, and divide the product by the thickness; six times the quotient will be the proper tensile strength if single-riveted, or one-sixth less if double-riveted.

Example.—What tensile strength should .45 inch iron have in a boiler 60 inches in diameter to carry a safety pressure of 150 pounds? $30\times150\div.45\times6=60,000$, the tensile strength single-riveted, or $60,000-\frac{1}{6}\times60,000=50,000$ tensile strength, double-riveted.

The rivet holes in all boiler plates should be punched to line true one with another.

Where holes are out of true they should be reamed instead of forced by drifting.

In caulking seams care should be taken to prevent grooving the plates.

SAN FRANCISCO, CAL.
PACIFIC COAST AGENT.

POWER PLANT OF THE WEST CHICAGO RY. CO., CONTAINING 8000 H. P. STIRLING BOILERS.

RULES FOR THE CARE OF STIRLING BOILERS.

THE steam gauge should stand at zero when the pressure is off, and it should show same pressure as the safety valve when that is blowing off. If not, one is wrong, and the gauge should be tested by one known to be correct.

Do not rely on glass gauges, floats or water alarms, but try gauge cocks. If they do not agree with water gauge, learn the cause and correct it. The Stirling Boiler works best on two gauges of water.

Gauge cocks and water gauges should be kept clean. The water gauge should be blown out frequently and passage to gauge kept clean.

In case of low water, immediately cover fire with ashes—wet if possible—or any earth that may be at hand. If nothing else is handy, use fresh coal; draw fire as soon as it can be done without increasing the heat. Do not turn on the feed, start or stop the engine or lift safety valves until the fires are out and the boiler cooled down.

Fire evenly and regularly, a little at a time. Moderately thick fires are most economical, but thick firing must be used where the draught is poor. Take care to keep the grates evenly covered and allow no air holes in the fire. Do not clean fires oftener than necessary.

All heating surfaces must be kept clean inside and out, or there will be a serious waste of fuel. The frequency of cleaning will depend on the nature of the fuel and water. As a rule, never allow over one-sixteenth of an inch of scale or soot to collect on the surfaces between cleanings. Man-holes should be removed every two or three weeks and surfaces examined, particularly in case of a new boiler, until proper

intervals have been established by experience. The exterior of tubes can be kept clean by use of blowing pipe and hose through openings provided for that purpose. In using smoky fuel, it is best to occasionally brush surfaces when steam is off.

When foaming occurs in a boiler, checking the outflow of steam will usually stop it. If caused by dirty water, blowing down and pumping will generally cure it. In cases of violent foaming, check the draught and fires. The Stirling Boiler never foams with good water, unless the water is carried too high. If found to prime, lower the water line. It should not be carried higher than two gauges.

Be sure that all openings for admission of air to the setting of boilers or flues, except through fire, are carefully closed. This is frequently an unsuspected cause of serious waste.

If feed water is muddy or salty, blow off a portion frequently, according to condition of water. Empty the boiler every week or two and fill up afresh. *Never empty the boiler while the brick is hot. Never pump cold water into a hot boiler.* Do not start to operate a new boiler until the brickwork has been thoroughly dried out under a slow fire.

If a boiler is not required for some time, empty and dry it thoroughly. If this is impracticable, then fill it quite full of water and put in a quantity of common washing soda. External parts exposed to dampness should receive a coating of linseed oil.

If, after starting boiler, there should be a formation of scale in rear tubes where feed water enters, use tube scraper furnished with boiler.

It is important that no accumulation of ashes on mud drum, between the tubes, should be allowed to form. The mud drum should not be bricked in solid, but should be suspended entirely independent of the brickwork, thus allowing for the play of the drum due to the contraction and expansion of the tubes.

BOILER TESTS.

THE object of boiler tests is to determine the number of pounds of water evaporated into steam by a given quantity of fuel, the quality of the steam furnished, and the possibilities of the boiler in the direction of forcing it in excess of its rated capacity. Their value, then, must be apparent, in that they show absolutely what a boiler is capable of doing, and, further, in that they enable the careful user to discover any sources of wasteful expenditure of fuel that may exist, and show him under what conditions the best results can be realized from his boiler.

For a long time tests were regarded as sort of dress parade affairs, where the boiler was made to do special work, on special occasions, and under special conditions, troublesome or impossible in every-day practice. This impression is a false one, and is being rapidly removed. Whilst it may be admitted that most tests are conducted under conditions that are intended to make the best showing for the boiler, there is no reason why these same conditions should not exist in the every-day operation of the plant. If a high evaporative efficiency in a test is due, as it frequently is, to greater care in cleaning the exterior and interior surfaces of the boiler properly, and to more intelligence on the part of the fireman in the care of his fires and regulation of his damper, then there is no reason why equally as good results may not be obtained, day in and day out, by an equal amount of care and an equal amount of intelligence on the part of the attendants.

In conducting a test it is usual to measure the amount of water evaporated per pound of fuel used, and to reduce the results to a fixed standard for the sake of comparing one test with another. This standard is technically known as "from

TESTS ON STIRLING BOILERS.

Name and Place.	Engineer.	Rating.	Duration Test.	Temperature of Feed.	Evap. per lb. Coal from and at 212°.	Evap. per lb. Combustible from and at 212°	Coal cons'd pr. sq. ft. grate, per hour.	Draught.	Moisture in Steam, per ct.	Temperat're of Escap'g Gases.	Per Cent Developed. Above Rating.	Per Cent Developed. Below Rating.	Kind of Fuel.
American Cereal Mills, Akron, O.....	F. A. Scheffler..	200	6.25	38.7	8.55	**9.59**	24.8	.46	....	553	60.	.....	Bitumin's Slack.
Mt. Lookout Coal Co., Wyoming, Pa.....	P. Hansen.....	450	6.	60.	9.79	**12.49**	15.2	.23	....	464	2.1	.....	Culm.
Frasch Soda Co., Cleveland, O.....	Chas. Hyde.....	200	6.	80.	8.93	**11.12**	19.6	.41	....	590	16.6	.....	Bitumin's Slack.
Edison Light Co., Grand Rapids, Mich....	M. E. Cooley....	200	12.	171.	9.81	**10.39**	18.9	.78	.45	409	6.21	.....	Montana Lump.
Consolidated Steel Wire Co., Allentown, Pa.	P. Hansen.....	250	6.75	59.3	6.90	**9.44**	24.8	...	1.75	420	12.	.....	Culm.
Lehigh Coal Nav. Co., Lansford, Pa.....	"	400	9.	175.	8.19	**10.10**	16.66	.10	1.33	425	3.	.....	Anthracite.
B. F. Goodrich Co., Akron, O.....	"	300	8.	70.9	9.26	**11.26**	17.63	.35	....	457	22.6	.....	Bitumin's Slack.
Cleveland (O.) Gen. Elec. Co.....	W. H. Chapman	400	8.	76.	9.37	**10.03**	17.12	.30	...	507	4.	.....	Pittsburg Lump.
❋Portland (Me.) St. Ry. Co.....	Geo. H. Barrus..	250	8.57	210.	11.02	**12.06**	11.69	.11	.06	487	.....	15.	Cumberland.
Lehigh Valley Traction Co., Allentown, Pa.	P. Hansen.....	600	10.	191.8	8.47	**11.27**	9.91	.3	....	358	.....	1.5	Buckwheat.
Lehigh & Wilkes-Barre Coal Co.....	Geo. H. Barrus..	125	9.24	42.	10.07	**11.45**	14.84	.16	Dry	485	28.	.....	No. 2 Buckwheat
❋ " " "	" ..	125	7.88	41.	9.31	**10.65**	28.28	.16	.5	654	132.	.....	"
" " "	" ..	125	7.22	42.	9.12	**10.74**	10.66	.16	....	462	8.	.....	Culm.
❋ " " "	" ..	125	7.36	43.	7.89	**9.95**	17.63	.16	....	543	44.	.....	"
Blackstone Mfg. Co., Blackstone, Mass....	Barrus & Evans	250	10.49	54.	10.91	**12.05**	13.46	.21	†	436	.....	2.	Cumberland.
❋Carnegie Mills, Pittsburg, Pa.....	R. T. Stewart...	300	5.	40.	8.35	**10.25**	.....	.65	.13	480	83.	.....	Pittsburg Lump.
Union Railway Co., Providence, R. I.....	Thos. Evans.....	250	9.7	66.	10.57	**11.61**	14.8	.75	1.75	308	6.	.....	Cumberland.
Lindell Railway Co., St. Louis, Mo.....	W. H. Bryan ...	300	9.	47.	7.82	**8.92**	.....	.77	.14	448	15.	.....	Illinois Lump.
Belle City St. Ry., Racine, Wis.....	D. P. Jones.....	200	8.	155.	8.59	**9.34**	17.81	.38	.98	485	14.	.....	"
" " "	"	200	8.	168.	11.44	**12.1**	13.32	.28	.91	480	15.	.....	Youghiogheny.
Marshall Kennedy Mil'g Co., Allegheny, Pa.	D. Ashworth....	600	8.	71.	9.67	**11.1**	17.2	.54	1.	421	.....	18.	Bitumin's Slack.
Toledo Water Works, Toledo, O.....	M. E. Cooley....	300	16.33	116.	10.38	**11.79**	21.7	.45	.41	503	6.	.....	Cumberland.

❋ For Capacity. † Superheated.

and at 212° per pound of combustible;" that is, computations are made under the assumption that the temperature of the feed water was 212°, that the steam was delivered at atmospheric pressure, and the coal was without ash.

The Stirling has been submitted to innumerable tests, under different conditions, and employing different kinds of coal. The tables and reports published herewith will prove of interest in this connection; the names of the engineers who have personally supervised the tests being a sufficient guarantee of their reliability.

TEST ON 300 H. P. STIRLING BOILER.

The following test was made by Professor M. E. Cooley, University of Michigan, upon a 300 Horse Power Stirling Boiler, at the Toledo (Ohio) Water Works:

DATE OF TEST, DECEMBER 8, 1894.

1.	Heating surface	3222 square feet.
2.	Grate surface	48.94 square feet.
3.	Ratio of grate to heating surface	1 to 60.58
4.	Duration of test	16.33 hours.
5.	Kind of fuel used	George's Creek, Cumberland.
6.	Barometric pressure	14.26 inches.
7.	Steam pressure per gauge	121.11 pounds.
8.	Chimney draught in inches of water	.455
9.	Temperature of feed water	116 58
10.	Temperature of escaping gases	503.88
11.	Temperature of boiler room	76.60 degrees.
12.	Pounds of coal burned	17,373 pounds.
13.	Pounds of refuse	1549 pounds.
14.	Pounds of combustible	15,828 pounds.
15.	Per cent of refuse	8.91 per cent.
16.	Coal burned per hour	1063.9 pounds.
17.	Coal burned per square foot of grate per hour	21.74 pounds.
18.	Total water evaporated (apparent)	158,302 pounds.
19.	Per cent of entrained moisture	0.416 per cent.
20.	Quality of steam	99.584 per cent.
21.	Total water actually evaporated	157,819 pounds.
22.	Water actually evaporated per pound of coal	9.082 pounds.
23.	Water actually evaporated per pound of combustible	9.971 pounds.
24.	Water actually evaporated per pound of coal from and at 212 degrees	10.383 pounds.
25.	**Water actually evaporated per pound of combustible from and at 212 degrees**	**11.4 pounds.**
26.	Rated horse power	300 horse power.
27.	Horse power developed during test	319.7 horse power.
28.	Total heat B. T. U. per pound of combustible	14,345
29.	Heat utilized by boiler B. T. U	11,009
30.	Per cent of efficiency	76.75 per cent.

TEST ON 200 H. P. STIRLING BOILER.

The following test was made by D. P. Jones, M. E. (Chief Engineer U. S. Navy, retired), upon a 200 Horse Power Stirling Boiler at the Belle City Electric Street Railway Company, Racine, Wis. :

DATE OF TEST, JANUARY 24, 1895.

1.	Heating surface	2300 square feet.
2.	Grate surface	52 square feet.
3.	Ratio of grate to heating surface	1 to 44.1
4.	Duration of test	8 hours.
5.	Kind of fuel used	Youghiogheny, Pittsburgh Lump.
6.	Barometer	29.85
7.	Steam pressure per gauge	129 pounds.
8.	Chimney draught in inches of water	0.28
9.	Temperature of feed water	168 degrees.
10.	Temperature of escaping gases	480 degrees.
11.	Temperature of boiler room	50 degrees.
12.	Pounds of coal burned	5543 pounds.
13.	Pounds of refuse	504 pounds.
14.	Pounds of combustible	5239 pounds.
15.	Per cent of refuse	5¼ per cent.
16.	Coal burned per hour	692.9 pounds.
17.	Coal burned per square foot of grate per hour	13.32 pounds.
18.	Total water evaporated (apparent)	57,990 pounds.
19.	Per cent of entrained moisture	0.91 per cent.
20.	Quality of steam	99.09 per cent.
21.	Total water actually evaporated	57,462 pounds.
22.	Water actually evaporated per pound of coal	10.36 pounds.
23.	Water actually evaporated per pound of combustible	10.96 pounds.
24.	Water actually evaporated per pound of coal from and at 212 degrees	11.34 pounds.
25.	**Water actually evaporated per pound of combustible from and at 212 degrees**	**12.00 pounds.**
26.	Rated horse power	200 horse power.
27.	Horse power developed during test	229 horse power.
28.	Total heat B. T. U. per pound of combustible	14,581
29.	Heat utilized by boiler B. T. U.	11,592
30.	Per cent of efficiency	79.5 per cent.

TEST ON 600 H. P. STIRLING BOILERS.

The following evaporative test was made on 600 Horse Power Stirling Boilers at the Marshall Kennedy Milling Company Mills, Allegheny City, Pa., by D. Ashworth, M. E., of Pittsburg, Pa.:

DATE OF TEST, SEPTEMBER 20, 1894.

1.	Heating surface	6900 square feet.
2.	Grate surface	90 square feet.
3.	Ratio of grate to heating surface	76.6 square feet.
4.	Duration of test	8 hours.
5.	Kind of fuel used	Bituminous slack.
6.	Barometer	29.
7.	Steam pressure per gauge	95.
8.	Chimney draught in inches of water	54.
9.	Temperature of feed water	71 degrees.
10.	Temperature of escaping gases	421 degrees.
11.	Temperature boiler room	76 degrees.
12.	Pounds of coal burned	13,988.6 pounds.
13.	Pounds of refuse	1827.5 pounds.
14.	Pounds of combustible	12,161.1 pounds.
15.	Per cent of refuse	13 per cent.
16.	Coal burned per hour	1748.6 pounds.
17.	Coal burned per square foot grate	17.2 pounds.
18.	Total water evaporated (apparent)	114,190 pounds.
19.	Per cent of entrained moisture	1 per cent.
20.	Quality of steam	99 per cent.
21.	Total water actually evaporated	114,076 pounds.
22.	Water actually evaporated per pound of coal	8.16 pounds.
23.	Water actually evaporated per pound combustible	9.39 pounds.
24.	Water actually evaporated per pound coal from and at 212 degrees	9.67 pounds.
25.	**Water actually evaporated per pound combustible from and at 212 degrees**	**11.1 pounds.**
26.	Rated horse power	600
27.	Horse power developed during test	490.7
28.	Total heat B. T. U. per pound of combustible	14,575
29.	Heat utilized by boiler B. T. U	10,712
30.	Per cent of efficiency	73.6

TEST ON 250 H. P. STIRLING BOILER.

The following test was made by Mr. Geo. H. Barrus, M. E., upon the 250 Horse Power Boiler of the Portland Railroad Company Power Station, Portland, Maine:

DATE OF TEST, JANUARY 23, 1894.

1.	Heating surface	2552 square feet.
2.	Grate surface	57 square feet.
3.	Ratio of grate to heating surface	1 to 44.7
4.	Duration of test	8.57 hours.
5.	Kind of fuel used	George's Creek, Cumberland.
6.	Barometer	
7.	Steam pressure per gauge	123.3 pounds.
8.	Chimney draught in inches of water	0.11
9.	Temperature of feed water	210 degrees.
10.	Temperature of escaping gases	478 degrees.
11.	Temperature of boiler room	
12.	Pounds of coal burned	5713 pounds.
13.	Pounds of refuse	490 pounds.
14.	Pounds of combustible	5223 pounds.
15.	Per cent of refuse	8.6 per cent.
16.	Coal burned per hour	666.6 pounds.
17.	Coal burned per square foot of grate	11.69 pounds.
18.	Total water evaporated (apparent)	60,217 pounds.
19.	Per cent of entrained moisture	0.06 per cent.
20.	Quality of steam	99.94 per cent.
21.	Total water actually evaporated	60,181 pounds.
22.	Water actually evaporated per pound of coal	10. 54 pounds.
23.	Water actually evaporated per pound of combustible	11.5 pounds.
24.	Water actually evaporated per pound of coal from and at 212 degrees	11.025 pounds.
25.	**Water actually evaporated per pound of combustible from and at 212 degrees**	**12.06 pounds.**
26.	Rated horse power	250
27.	Horse power developed during test	213
28.	Total heat B. T. U. per pound of combustible	14,992
29.	Heat utilized by boiler B. T. U	11,650
30.	Per cent. of efficiency	77 per cent.

TESTS ON 125 H. P. STIRLING BOILER.

The following tests were made by Mr. Geo. H. Barrus, to determine the economy and capacity of a 125 Horse Power Stirling Boiler, using No. 2 Buckwheat coal, with forced draught, at the Lehigh & Wilkesbarre Coal Company's No. 5 Shaft, Wilkesbarre, Pa. No allowance was made for steam used by the blower for forced draught.

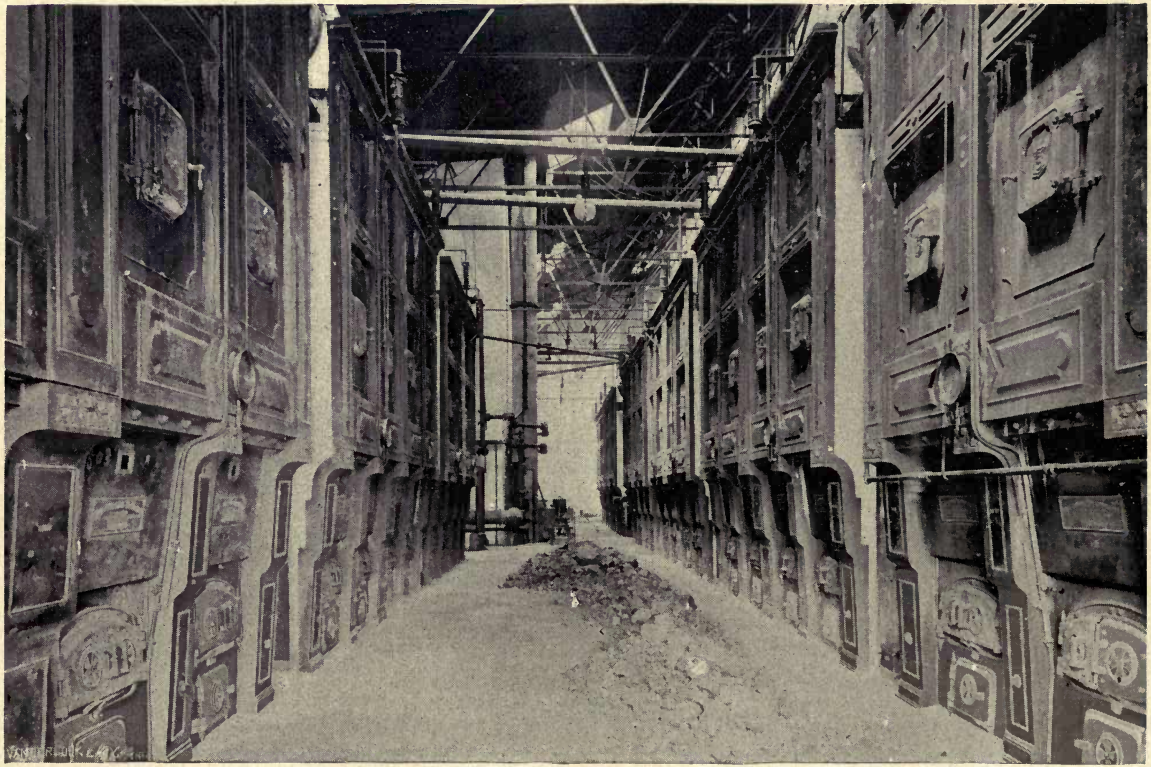
Date of test	December 2, 1894.	December 3, 1894.
Heating surface	1437 square feet.	1437 square feet.
Grate surface	38 square feet.	38 square feet.
Ratio of grate to heating surface	1 to 37.8	1 to 37.8
Duration of test	9.24 hours.	7.88 hours.
Kind of fuel used	No. 2 Buckwheat.	No. 2 Buckwheat.
Chimney draught in inches of water	0.16	0.16
Temperature of feed water	42 degrees.	41 degrees.
Temperature of escaping gases	485 degrees.	654 degrees.
Pounds of coal burned	5020 pounds.	8468 pounds.
Pounds of refuse	603 pounds.	1068 pounds.
Pounds of combustible	4417 pounds.	7400 pounds.
Per cent of refuse	12 per cent.	12.6 per cent.
Coal burned per hour	564.9 pounds.	1074.6 pounds.
Coal burned per square foot of grate	14.84 pounds.	28 28 pounds.
Total water evaporated (apparent)	41,966 pounds.	64,989 pounds.
Total water actually evaporated	41,966 pounds.	64,664 pounds.
Water actually evaporated per pound of coal	8.32 pounds.	7.67 pounds.
Water actually evaporated per pound of combustible	9.5 pounds.	8.73 pounds.
Water actually evaporated per pound coal from and at 212°	10.07 pounds.	9.31 pounds.
Water actually evaporated per pound combustible from and at 212°	**11.45 pounds.**	**10.65 pounds.**
Rated horse power	125	125
Horse power developed during test	159.6	**290**
Total heat B. T. U., per pound combustible	13,887	13,887
Heat utilized by boiler B. T. U.	11,060	10,289
Per cent of efficiency	79.6 per cent.	74 per cent.

TESTS ON 125 H. P. STIRLING BOILER.

The following tests to determine the economy and capacity of a 125 Horse Power Stirling Boiler, using culm as fuel, with forced draught, were made by Mr. Geo. H. Barrus, at the Lehigh & Wilkesbarre No. 5 Shaft, Wilkesbarre, Pa. No allowance was made for the steam used for forced draught.

Date of test	December 11, 1894.	December 12, 1894.
Heating surface	1437 square feet.	1437 square feet.
Grate surface	45 square feet.	45 square feet.
Ratio of grate to heating surface	1 to 31.9	1 to 31.9
Duration of test	7.22 hours.	7.36 hours.
Kind of fuel used	Culm, No. 5 Shaft.	Culm, No. 4 Shaft.
Chimney draught in inches of water	0.16	0.16
Temperature of feed water	42 degrees.	0.43 degrees.
Temperature of escaping gases	462 degrees.	543 degrees.
Pounds of coal burned	3462 pounds.	5839 pounds.
Pounds of refuse	522 pounds.	1207 pounds.
Pounds of combustible	2940 pounds.	4632 pounds.
Per cent of refuse	15 per cent.	20 per cent.
Coal burned per hour	479.5 pounds.	793.3 pounds.
Coal burned per square foot of grate	10.66 pounds.	17.63 pounds.
Total water evaporated (apparent)	26,080 pounds.	38,071 pounds.
Water actually evaporated per pound of coal	7.53 pounds.	6.52 pounds.
Water actually evaporated per pound of combustible	8.87 pounds.	8.21 pounds.
Water actually evaporated per pound of coal from and at 212°	9.12 pounds.	7.89 pounds.
Water actually evaporated per pound of combustible from and at 212°	**10.75 pounds.**	**9.95 pounds.**
Rated horse power	125	125
Horse power developed during test	134.8	**181.6**
Total heat B. T. U. per pound of combustible	13,985	14,044
Heat utilized by boiler B. T. U.	10,380	9,611
Per cent efficiency	74.2 per cent.	68.4 per cent.

PACIFIC COAST AGENT.



8000 H. P. STIRLING BOILERS AT WEST CHICAGO STREET R'Y CO.'S, WESTERN AVENUE AND WASHINGTON BOULEVARD, CHICAGO, ILL.

TESTIMONIALS.

We submit herewith a few of the many letters that have from time to time been written by the users of the Stirling, in relation to its merits, superiority, etc.

CINCINNATI, COVINGTON & NEWPORT STREET RY.

CLEVELAND, O., May 21, 1894.

MR. F. M. FABER, Esq.,
Agent "Stirling Boiler," Pittsburgh, Pa.

Dear Sir:—In response to your favor of the 19th, would say that I have used the Stirling boilers at Cleveland, O., Newport, Ky., and Evansville, Ind., for Street R. R. work with great satisfaction for the past two or three years. Be assured if I were in need of a plant for my own use I should order a Stirling in preference to any water tube boiler in the market.

Yours very truly,

JOHN J. SHIPHERD.

LEWIS A. RILEY & CO.

PHILADELPHIA, April 7, 1894.

JAMES MEILY, Esq., Philadelphia.

Dear Sir:—I take pleasure in stating that we have in operation for the last six months two plants of your Stirling boilers of 250 H. P. each, and are pleased with the results up to this time. They seem to be well built and on correct principles, are economical of fuel and labor, and rapid steam raisers.

Yours truly,

LEWIS A. RILEY & CO.

JAMESTOWN STREET RAILWAY CO.

JAMESTOWN, N. Y., May 17, '94.

GENTLEMEN:—We are in receipt of your communication under date of May 15, requesting our experience with the "Stirling Water Tube Safety Boilers" and in reply would say that we have had remarkable success with the same.

We started June 11, 1890, with one battery of two boilers, each 150 H. P. Stirling boilers, which furnished steam for three 150 H. P. Compound Condensing Engines, manufactured by the Phœnix Iron Works of Meadville, Pa. We found that it was utterly impossible for us to prevent the steam blowing off nearly all the time, and finally discontinued the use of one of the 150

H. P. boilers, and for a long time ran the three engines with the other, and without seemingly any additional labor.

Of course, we do not believe that it is advisable to follow up the practice of this kind with any boiler, as in time it would necessarily be very disastrous, but they are certainly great steamers and very economical.

The battery of boilers has not cost us $1.00 for repairs on the tubes since we purchased them. They are certainly very easy to clean and handy to take care of. You certainly can make no mistake in purchasing the Stirling boilers.

Yours most respectfully,

JAMESTOWN STREET RAILWAY CO.

PHILIP D. ARMOUR,
205 LA SALLE ST.

CHICAGO, June 2, 1894.

THE STIRLING COMPANY,
Pullman Building, Chicago.

Gentlemen:—We have in use at our packing house and glue factory, and also at the Armour Institute, considerably over $100,000 worth of your boilers, and they have given us entire satisfaction; in fact, we consider them much more preferable to any boiler we have ever used. They are a little expensive to start with, but in the end we consider them very economical, and our engineers are after us daily to replace what old ones we have with yours. Owing to the hard times and the curtailment of expenses, however, we are going a little slow in making improvements. Ultimately we expect to use your boiler only, as we consider there are none better.

Respectfully yours,

PHILIP D. ARMOUR.

THE AMERICAN GLUCOSE COMPANY.

PEORIA, ILL., April 14, 1894.

THE STIRLING COMPANY,
Chicago, Ill.

Gentlemen:—Referring to your favor of late date, we are pleased to state that the boiler you installed in our plant is giving excellent satisfaction.

Yours very truly,
THE AMERICAN GLUCOSE COMPANY,
G. W. Powers.

TOLEDO CONSOL'D STREET RY. CO.
ALBION E. LANG, PRES.,
Toledo, O.

TOLEDO, O., April 27, 1894.

ARBUCKLE, RYAN & CO., City.

Gentlemen:—In reply to your inquiry would say that we purchased 600

H. P. of Stirling boilers about four years ago, and two years later duplicated our order, so that we are now using 1,200 H. P. daily.

We have always used oil or gas as fuel.

The fact that we duplicated our order for a second battery is the best recommendation we can give the Stirling boiler.

Respectfully yours,

THE TOLEDO CONSOL'D STREET RY. CO.,
By Albion E. Lang.

J. G. MATTINGLY CO.
DISTILLERS.

LOUISVILLE, KY., April 17, 1894.

GENTLEMEN:--We are in receipt of yours of the 6th inst., making inquiry about the Stirling boilers. Replying to same will say that in the spring of '93 we bought one boiler from them and it gave such good general satisfaction that we, in the fall, ordered two more, giving us a total of 1,200 H. P. We are very well pleased with them, being the greatest steamers we ever saw, and besides they save coal. Yours truly,

J. G. MATTINGLY CO.,
By S. P. Jones, Sec. and Treas.

ARMOUR PACKING CO.
OFFICE OF THE SUPERINTENDENT.

KANSAS CITY, U. S. A., May 26, 1894.

MESSRS. STIRLING CO.,
Chicago, Ill.

Gentlemen:—In answer to your favor of the 17th inst., beg to state that the Stirling boilers have given good satisfaction ever since we overhauled the first battery that was put in. We never had any trouble with the last batteries that are in our new beef house, they having given good satisfaction from the time we started the house up, and are doing good work yet. We are perfectly satisfied with the boilers and think they have some merits as to scaling that make them preferable to any other water tube boiler we have used. Truly yours,

G. W. TOURTELLOT, *Supt.*

THE NATIONAL BANK OF COMMERCE.

DENVER, COLO., June 8, 1894.

MR. F. D. WALLAKER,
Western Agent Stirling Company, Denver, Colo.

Dear Sir:—Replying to your request of even date herewith, I take pleasure in saying that the two 100 H. P. Stirling boilers installed by your company in the Cooper Building, Denver, Colo., which have been in active

operation since October last, have to date given entire satisfaction. All the claims made for the boilers have been sustained, and I am free to express my entire satisfaction in the choice of the Stirling in preference to other types of boilers.

I shall be glad at any time to have parties contemplating buying call at my building and see the boilers in operation.

With the best wishes for your continued success, I beg to remain,

Yours very truly,

J. A. COOPER.

GOEBEL BREWING CO.

DETROIT, MICH., April 19, 1894.

DEAR SIRS:—In reply to yours of the 18th inst., would say that we have used the "Stirling Boiler" for the last year and a half, and have found same to give perfect satisfaction both as regards "well steaming" and "economical consumption of fuel and repairs."

Yours respectfully,

GOEBEL BREWING CO.,
F. W. Brede, Sec.

THE AMERICAN CEREAL COMPANY.

AKRON, OHIO, Nov. 10th, 1893.

THE STIRLING COMPANY,
Barberton, Ohio.

Dear Sirs:—It gives me pleasure to advise you that we have been successfully using the battery of two boilers placed by you for us since their installation in June, 1892. They have given us very good service, steaming freely, and their consumption of coal has been satisfactory to us. We recommend them highly as we can find no fault in them after using them for about a year and a half. Would be pleased to answer any inquiries from other manufacturers in regard to them. We remain,

Yours truly,

THE AMERICAN CEREAL CO.
J. H. Andrews.

THE F. GRAY COMPANY.

PAPER MAKERS, FELTS AND JACKETS, BLANKETS AND FLANNELS.

PIQUA, OHIO, April 16, 1894.

DEAR SIRS:—Replying to your favor of the 14th inst., inquiring about the Stirling Water Tube Boiler, will say that we have had in use one 200 H. P. for two years, having displaced one Babcock & Wilcox. We find it to be an

excellent steamer and very economical to run. After due examination of various boilers, we feel that it is the most economical boiler and easiest to handle of any now in use.

Yours truly,

THE F. GRAY CO.,
W. C. Gray, Treas.

CONSOLIDATED STEEL & WIRE CO.

ST. LOUIS, March 7, 1894.

MR. LOUIS ARNOLD,
Boston, Mass.

Dear Sir:—Yours of the 5th duly received and carefully noted. We have had the Stirling boiler in use in our works since January, 1892, and we consider it one of the most reliable and satisfactory boilers we have ever had in our plant. It is economical and easy to keep clean.

Yours truly,

CONSOLIDATED STEEL & WIRE CO.
James O'Brien, Sup't.
W. J. Drain, Eng'r.

CINCINNATI, NEWPORT & COVINGTON ST. RY. CO.

CINCINNATI, OHIO, Dec. 11, 1893.

C. C. COYLE, Esq.,
Cincinnati, Ohio.

Dear Sir:—Our 500 H. P. Stirling boilers were opened last Saturday, December 9, for the first time after a run, night and day, for over three months. I must say that the result has been a complete surprise to us, as not a particle of scale or deposit was found in either boiler, both being as clean as they were the day they were installed, and could have been fired again immediately after the examination was made.

Our Babcock boilers, while running under precisely the same conditions, found scale and required seven days of active labor to clean. A large proportion of the water used was from the city supply and also direct from the Licking River.

Yours truly,

CINCINNATI, NEWPORT & COVINGTON ST. RY. CO.,
W. Kelly, Chief Eng'r.

NORDYKE & MARMON COMPANY.

INDIANAPOLIS, IND., Jan. 17th, 1894.

THE STIRLING COMPANY,
Chicago, Ill.

Gentlemen:—For some months past we have been using two of your 150 H. P. boilers here in our works, which are giving good service and good

ONTGOMERY ST.
N FRANCISCO, CAL.
IC COAST AGENT.

THE MILLS BUILDING, SAN FRANCISCO, IN WHICH 450 H. P. STIRLING BOILERS ARE INSTALLED.

satisfaction. Something over two years ago, we put in two 200 H. P. boilers in a large milling plant that has used these boilers continuously since then. We have watched their operation quite closely and are glad to be able to say that they have given excellent satisfaction. Our experience with your boilers, together with our observation of and acquaintance with other water tube boilers, still confirms us in the belief that you have decidedly the best water tube boiler that is now made.

Yours truly,

NORDYKE & MARMON CO.
D. W. Marmon, Sec'y.

AKRON IRON COMPANY.

AKRON, O., February 3, 1894.

THE STIRLING COMPANY,
Chicago, Ill.

Gentlemen:—Replying to your favor of the 1st inst., beg to say that the Stirling boiler which was placed in our mill to utilize the waste heat of a heating furnace, now, after two years of almost constant use, we find it is an excellent steamer, and, upon a careful examination on Monday of this week, was found to be in excellent condition.

Your truly,

J. A. LONG, Receiver.
A. P. Baldwin, Genl. Sup't.

THE SPRINGFIELD RY. CO.

SPRINGFIELD, OHIO, May 16, 1894.

THE STIRLING COMPANY,
Chicago, Ill.

Gentlemen:—Acknowledging receipt of your esteemed favor of the 15th, we beg to say in reply that we installed one 125 H. P. Stirling boiler in a plant in Defiance, O., in 1891, two 250 H. P. boilers in Springfield, in 1892, and two 250 H. P. in Bay City, Mich., in 1893.

We have not incurred a single dollar's expense in the maintenance of any of these boilers, although the water at all of the above named places is very bad. These boilers, used in connection with Hoppes Live Steam Purifier, are to-day in excellent condition. I will say further that the Springfield boilers have not been cool for the past 12 months, except for a long enough time to make internal inspection.

We shall be in the market very soon for additional boilers, and will consider the installation of no boiler other than the Stirling.

Very respectfully,

S. L. NELSON,
General Manager.

EMERSON, TALCOTT & CO.

ROCKFORD, ILL., May 4, 1894

GENTLEMEN:—Yours of the 3d received, inquiring about the Stirling boiler. We have used a Stirling boiler now for about four years and find it very satisfactory; very quick maker of steam, and we would not know how to get along without it if we could not replace it with another of the same kind.

Yours truly,

EMERSON, TALCOTT & CO.

ERNST & COMPANY.

NEW ORLEANS, May 5, 1894.

GENTLEMEN:—Your favor of the 3d inst. to hand.

We have been using in our new mill 200 H. P. Stirling boilers, and are pleased with them. They are easily handled and great steam makers. We have since added 125 H. P. to our old plant, and should we want more power we should certainly put in the "Stirling."

Very respectfully yours,

ERNST & COMPANY.

ARMOUR GLUE WORKS,

CHICAGO, ILL.

CHICAGO, ILL., February 15, 1894.

STIRLING BOILER COMPANY,

Pullman Building, City.

Dear Sirs:—In reply to your inquiry as to your boilers, of which we have 1,050 H. P., we are very much pleased with them indeed, as the results we get are very gratifying. We have three of your boilers of 350 H. P. each, which have been in constant service for the past eighteen months, night and day, and have been worked from 50 to 75 H. P. above their rated capacity, and the matter of repairs is about one-quarter that of any of the boilers we have in our plant, and as fast as the tubular boilers give out I shall recommend your boilers. I have been a little slow in expressing myself over your boilers, as I do not get enthusiastic over anything new. I believe there is only one way of testing a boiler, and that is in a practical test, such as we have made and are willing to abide by. Our boilers can be seen in operation at any time by any one who is interested in boilers, and I will be pleased to answer any inquiry concerning them.

Yours very truly,

C. W. BROWN,
Chief Engineer.

CENTENNIAL EUREKA MINING CO.

SALT LAKE CITY, UTAH, March 20, 1893.

ARBUCKLE, RYAN & CO.,
Toledo, Ohio.

Gentlemen:—Answering yours of the 1st inst., I would say, the Stirling boilers put up by the Centennial Eureka Mining Co., at their mine, Eureka, Utah, have exceeded our expectations.

We had an excellent opportunity to test the Stirling as compared with the Horizontal Tubular Boilers, as we were running both at the same time, drawing water from the same tank and using coal from the same bin.

The result of our observation was:

1st. The Stirling boilers required 30% less coal.

2d. The Stirling boilers, after a run of 60 days, had but a light sandy deposit of lime in the rear steam drum, and a short distance down the tubes entering that drum, while the Tubular boilers, running only 30 days, had a scale of lime ¼ inch thick on the flues and shell.

In fact, we feel we cannot say enough in the praise of the Stirling boiler.

Respectfully yours,
J. D. KENDALL, Sup't.

THE B. F. GOODRICH COMPANY.

AKRON RUBBER WORKS.

J. H. DAY & CO., AKRON, OHIO, April 17, 1894.
Cincinnati, O.

Dear Sirs:—We have your inquiry of the 14th inst., regarding satisfaction of the Stirling boiler in our factory. We have had this boiler in operation for a period of 2½ years, and are pleased to say that it has given entire satisfaction, both as to steaming qualities and economy, and the cost of repairs on the boiler has been very small. We have not as yet been compelled to replace a tube, which fact we consider remarkable inasmuch as our water is especially bad, and the extreme length of time it has been in constant operation. The last test made of the Stirling showed an evaporation of 11.3 lbs. of water to 1 lb. of combustible, which you will admit is a magnificent result.

We cannot say too much in favor of the "Stirling," as we have found it even more than represented.

Trusting this will enable you to make your choice, we are,

Yours truly, B. F. GOODRICH CO.

AMERICAN STEEL CASTING COMPANY.

STEEL CASTINGS.

ALLIANCE, OHIO, April 20, 1894.

GENTLEMEN:—Answering yours of the 18th, we are pleased to state that

the Stirling boilers are giving us first-rate service in every way. The economy in the use of coal is very marked and the handling simple and economical. We are using stokers in connection with these boilers, and slack coal, and we find the arrangement to be entirely satisfactory. We have had no experience with water tube boilers of other makes, but have no hesitancy in recommending this style.

Yours truly,

AMERICAN STEEL CASTING CO.,

——— Edw. Yeomans, Sup't.

F. E. EDBROOKE & CO.

ARCHITECTS.

MR. F. D. WALLAKER, DENVER, COLO., June 6, 1894.

Western Agent, The Stirling Co., Denver, Colo.

Dear Sir:—In reply to your inquiry in reference to the two 100 H. P. Stirling boilers placed in the Cooper Building, of this city, by your company, under our supervision about one year ago, will say that they have been used constantly since that time and are giving the best of satisfaction. They are all that you claim them to be, and we believe are in every particular according to your guarantee.

Yours respectfully,

F. E. EDBROOKE & CO.,

——— Architects.

HEFFNER & COMPANY, SAGANORE MEAL MILLS.

CIRCLEVILLE, OHIO, April 6, 1893.

THE CRANE & BREED MANF'G CO.,

Cincinnati, Ohio.

Gentlemen:—In reply to yours of March 31st, we have been using a Stirling Water Tube Boiler for about two years. We clean out every three months and find it always in good shape. Our water is very limy but we have no trouble with scaling in boiler since we have been using the Stirling boiler, and we run six days in the week. We use the very lowest price fuel, such as slack, or nut and slack, and have reduced our fuel expense fully one-half since using the Stirling boiler.

Yours, etc.,

HEFFNER & CO.

P. S.—We think the Stirling boiler is the best boiler in use to-day, as well as the safest.

———

THE CLEVELAND CITY RAILWAY.

CLEVELAND, OHIO, January 24, 1894.

MR. F. E. BRUCE, AGT.,

The Stirling Company, Cleveland, Ohio.

Dear Sir:—I take pleasure in stating that the battery of two boilers, aggregating 750 H. P., of your Company's manufacture, which we started up

the latter part of last August in our cable power house, have given entire satisfaction in every way. During the recent heavy snow storms they ran both the St. Clair street electric and the cable lines without assistance, developing over 900 H. P., as shown by diagrams taken from the engines. This without forcing. After running for eight weeks night and day, they were opened and found absolutely free from scale, with the exception of a slight deposit in the upper portion of the tubes connecting with the rear upper drum. Two laborers were put to work cleaning them and in less than six hours from the time they went to work opening up, they had them cleaned, washed out, and sealed ready for steaming. Ten days ago one of the boilers was opened a second time, and as before a *very* slight deposit was found near the top of the rear tubes, while the middle and front banks were as clean as when first started. So far the boilers have not cost a dollar for maintenance nor repairs. The workmanship is first-class in every particular, and is, in fact, as good as I have ever seen in a boiler. They are as good steaming boilers as I have ever used.

Altogether I am more than satisfied, and am glad to add my praises to those of your many patrons. You have my permission to use or publish this letter, if you so desire. Very truly yours,

THOMAS SHEHAN,
Engineer.

MALTASE MANUFACTURING CO., LTD.,
221 North 15th St., above Susquehanna Ave.

MR. JAMES MEILY, Manager, PHILADELPHIA, June 15, 1894.
The Stirling Company, 418 Walnut St., Philadelphia, Pa.

Dear Sir:—The 100 H. P. Stirling boiler you installed at our manufactory early in 1892 has been in constant operation for more than two years. The results are all we expected, and more than fulfill the claims made for the Stirling system as to economy and efficiency, and in the matter of repairs we are glad to say the boiler has cost us nothing.

We unhesitatingly recommend in writing (as we have frequently done to inquirers) your Stirling boiler, and if we were to put in additional steam plant, it would surely be of the Stirling system.

Yours truly,

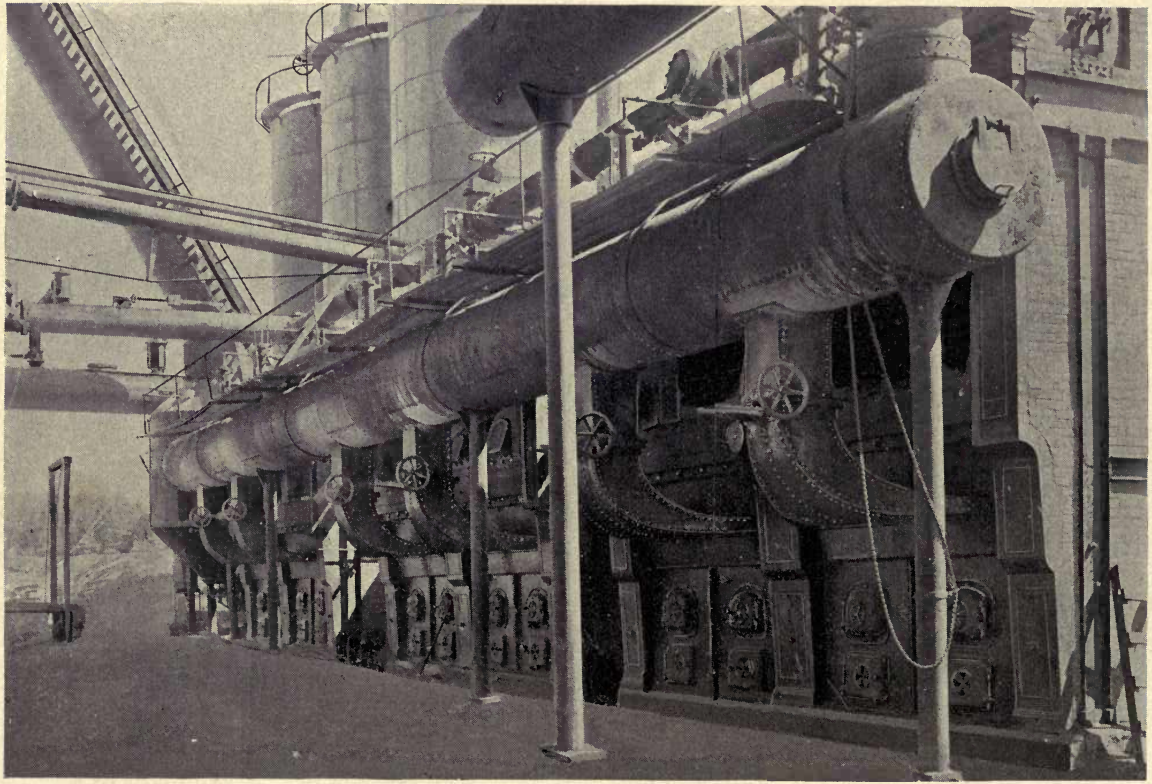
MALTASE MFG. CO., LTD.
Per Hermann.

HULL ELECTRIC LIGHT & POWER CO.
42 Court Street.

J. BRADFORD SARGENT, Esq., BOSTON, MASS., June 11, 1894.
Stirling Boiler Co., Boston, Mass.

Dear Sir:—We have been running two of your Water Tube Safety Boilers, 150 H. P. each, at our station at Nantasket, since December, 1892, and are

SAN FRANCISCO, CAL.
PACIFIC COAST AGENT.



1200 H. P. STIRLING BOILERS AT POUGHKEEPSIE IRON CO., POUGHKEEPSIE, N. Y., EQUIPPED FOR THE UTILIZATION OF BLAST FURNACE GASES.

pleased to say that they have given us entire satisfaction. Outside of some unimportant repairs on brickwork the cost of keeping them in order has been very trifling. They are subject to frequent inspection, both internal and external, and in no case has any fault been found with them.

Very truly yours,

HULL ELECTRIC LIGHT & POWER CO.
Geo. F. McKay, Manager.

THE NATIONAL SEWER PIPE CO.

BARBERTON, OHIO, June 25, 1894.

MR. E. R. STETTINIUS,
Treasurer Stirling Co., Chicago, Ill.

Dear Sir:—The battery of five 212½ horse power boilers which we bought of your Company and have had in operation night and day since May 27, 1891, have given perfect satisfaction, and we believe them to be by far the best boilers of any with which we have had any experience.

Very truly yours,

H. A. ROBINSON, Gen'l Mgr.

TOLEDO WATER WORKS.

TOLEDO, OHIO, December 26, 1894.

THE STIRLING COMPANY,
Chicago, Ill.,

Messrs:—In reply to yours of the 25th inst., asking for information as to the Stirling Boilers put in by your Company at the Water Works Pumping Station at this place (being 1,200 horse power in four 300 horse power units), we have this to say: We can most cordially and unhesitatingly recommend your boilers. They are giving us most excellent service.

We had an official test of the boilers a short time ago and they developed an evaporation of 11.33 pounds. We think this is a very good showing, as by the terms of your contract with us you only guaranteed 10 pounds, and what makes us especially pleased with your boilers is that the work and the duty which they developed at the time of the official test is only a fair average of what they are doing right along. The real merit of a boiler is not the high duty which a boiler may develop under certain favorable conditions, but the work which it will perform right along day after day, and in this respect your boilers are giving us great satisfaction, exceeding our anticipations.

The Chief Engineer at the Pumping Station has been making from time to time a number of tests on his own account, and he has found that the duty developed at the official test was about the same as the duty we are developing every day in actual work. And besides we keep an accurate account each day of the number of gallons of water pumped and the number

of pounds of coal used. We have a stand pipe system and use high pressure, and our average lift is 200 feet. We have been using what is called coarse slack, or pea and slack mixed, which costs us $1.20 per ton of 2,000 pounds. Using this coal at the price named it is costing us on an average (it will of course vary a little on different days) about $1.79 to pump a million gallons of water. In this computation we include the coal used for running the dynamo which furnishes the plant with electric lights, and also for heating the buildings and old engines. So that after deducting coal used for these purposes, and we have made a careful estimate in this respect, we pump on an average (of course, when we are pumping full capacity of the engine, we pump cheaper than when we are pumping a small amount; in the winter it costs a little more) a million gallons of water 200 feet high for $1.62 worth of fuel. We may be mistaken, but we think, taking into consideration the extent of our lift, we are pumping water cheaper than any plant in the country. And while we cannot attribute our success in this respect entirely to your boilers, we do think that they should come in for a large share of the credit.

In addition we will say further, that the water which we have been using until very lately was quite roily and dirty, and the arrangement of your boilers is such that we find the rear bank of tubes in connection with the lower drum causes the sediment to settle in the lower drum, thus enabling us to use dirty and roily water without any trouble or causing the tubes to scale.

In conclusion we can unhesitatingly say that your boilers have given us great satisfaction, and that were we to purchase again we should certainly purchase the Stirling Boiler in preference to any other that we know of.

Very truly yours,

L. K. PARKS, DANIEL C. SHAW, WILLIAM JONES, } Water Works Trustees Toledo, Ohio.

We fully concur in the above.

T. R. COOK, Sup't.
O. F. CONOVER, Chief Engineer.

ADRIANCE, PLATT & CO.
HARVESTING MACHINERY.

POUGHKEEPSIE, N. Y., March 19, 1895.

MR. E. B. GALLAHER,
253 Broadway, New York.

Dear Sir:—We have two Stirling Boilers in use of 125 horse power each. We have also two Tubular Boilers each 16 feet by 48 inches, having 49 three-inch tubes in each boiler, with return flue over the top of boilers. After

using the Stirling over a year, I can say that I would use no other. I studied the matter most thoroughly before purchasing, and feel somewhat proud that my judgment led me into no mistake. They are economical in fuel, easily kept clean and have needed no repairs. They have had steam on day and night since we have had them. Our water is none too good, but, by the introduction of about 1½ pounds of soda ash in solution once a week, they are kept perfectly clean.

If there is any other information you require in regard to them, let me know.

I would mention that we carry 115 pounds of steam.

Yours truly,

THOS. S. BROWN,
Sup't A. P. & Co.

THE IMPERIAL INSURANCE COMPANY, LIMITED,
OF LONDON, ENGLAND.
PREVOST & HERRING, Agents,
PHILADELPHIA OFFICE: Imperial Building, 411 and 413 Walnut Street.

PHILADELPHIA, September 3, 1894.

JAMES MEILY, ESQ.
418 Walnut St., Philadelphia.

Dear Sir:—We have in use two boilers, one Stirling and one Return Tubular (the latter built by I. P. Morris Co.). The Return Tubular Boiler has been running eleven years, and has cost in the neighborhood of $600 for repairs. The Stirling Boiler has been running for five years at no cost for repairs.

Since putting in the Stirling Boiler, five years ago, it has been running constantly, while the Return Tubular Boiler has been running during the winter season only, as an auxiliary.

The Stirling Boiler has given entire satisfaction in every respect.

Yours truly,

JAMES K. MCDONOUGH, Chief Engineer.

THE JOSEPH KOHNLE BREWING CO.'S MONTANA MALT BEER.
1715-1723 Buttonwood Street.

PHILADELPHIA, August 23, 1894.

MR. JAMES MEILY,

Dear Sir:—We have carefully noted the expense of running and keeping in order our Stirling and Return Tubular Boilers, and find the difference is decidedly in favor of the Stirling. In fact, we have found the Stirling the most economical to run and less expensive to clean and keep in order than any boiler we have ever used.

Yours respectfully,

JOS. KOHNLE.

19 William Street, Room 50 to 52.

NEW YORK, January 9, 1895.

THE STIRLING BOILER COMPANY.

Dear Sirs:—I have pleasure in stating that since the remodelling of the "Cutting Building," some six years ago, where your boilers were placed here, I have found them the best steaming boiler, needing no repairs of any kind thus far, and above all lead anything I have seen in my thirty years' experience as an engineer.

Yours truly,

THOS. F. HYNES.

HAMILTON, OHIO, May 8, 1895.

E. R. STETTINIUS,

Treas. Stirling Co., Pullman Bldg., Chicago, Ill.

Dear Sir:—Your favor of the 3d was duly received.

The Stirling boilers in our plant are doing well. They are economical, self-cleansing and work satisfactorily.

Yours truly,

THE NILES TOOL WORKS CO.,

R. C. McKinney,

Treas. & Gen. Mgr.

MUTUAL WHEEL CO.

MANUFACTURERS OF CARRIAGE WHEELS.

MOLINE, ILL., May 14, 1895.

MR. JOHN COLLEY,

Care of Stirling Company, Chicago.

Dear Sir:—In reply to your inquiry as to how we like the Stirling boilers, will say we have two 80 H. P. Stirling boilers, which have been in use three and a half years, and we have found them satisfactory in every respect. They are good steamers and are easily cleaned, and we take pleasure in recommending them to any one wanting to put in a modern plant.

Yours truly,

MUTUAL WHEEL CO.

Geo. McMaster, Mgr.

THE CLEVELAND FAUCET COMPANY.

CLEVELAND, OHIO, September 6, 1894.

MESSRS. LEWIS & ANDREWS,

City.

Gentlemen:—At the request of Mr. Bruce to give you our experience with the Stirling boiler, would say that we have used a 100 H. P. Stirling nearly

three years, and during this time the boiler has been in constant use, no repairs been needed. We use Lake Erie water through a heater, and without boiler compounds have no trouble with the tubes scaling. We have the boiler opened once in six or seven weeks, and within one hour the boiler is again ready for firing. The Stirling Company have made a number of improvements to rectify the liability for scaling in the rear bank of tubes, and while we have heard of a number of cases where the boiler has scaled badly, we are sure that the trouble arises from neglect.

The Stirling Boiler has given us the best of satisfaction, and as compared with the Return Tubular Boilers, we consider it more economical in fuel. There is also economy and safety at high pressure. We had a Return Tubular Boiler before we bought the Stirling, but we are so well pleased with the Stirling that we would not use any other kind, simply on account of its great economy. We should be pleased to give you any further information you may desire, and remain

Yours very truly,

THE CLEVELAND FAUCET CO.,
E. J. Weatherhead, Sup't.

PATTERSON, LA., February 15, 1895.

C. S. BURT CO., LIMITED,
New Orleans, La.

Gentlemen:—The 200 horse power Stirling boiler erected for us last year was used as a coal burner for our steam train. It originates steam rapidly, saving at least forty barrels of coal over the old boilers in eighteen hours, only one fireman firing the boilers with ease for eighteen hours.

We do not hesitate to recommend them to any one requiring boilers.

Yours very truly,

BOURDIER & BELLISSEIN.

LOREAUVILLE, LA., March 2, 1895.

MESSRS. C. S. BURT CO., LIMITED,
New Orleans, La.

Gentlemen:—I am glad to inform you that the two sets of 125 horse power each Stirling Boilers, bought from you last year and put in with bagasse burner, have given me first-class satisfaction. Had our sugar industry not received such a blow from last Congress, I would have taken out two sets of my two flue boilers which I fire with coal, and replaced them with Stirling Boilers, as I am more than satisfied it would have saved me a good deal on my coal bill. Yours truly,

A. GONSONLIN.

THE COOPER BUILDING, DENVER, CONTAINING 300 H. P. STIRLING BOILERS.

THE CARNEGIE STEEL COMPANY, LIMITED.
LOWER UNION MILLS.

MR. W. M. FABER, JR., PITTSBURG, PA., June 12, 1895.
Pittsburg, Pa.

Dear Sir:—We have in our 29th Street Mill 1200 horse power of Stirling Boilers which we installed over four years ago.

They have been in almost constant use double turn and have given entire satisfaction, and we can and do cheerfully recommend them on account of their construction as being very economical in the use of fuel and as being remarkably rapid steamers.

We wish also to call attention to the facility with which tubes can be cleaned and repairs made when necessary.

The total cost of repairs on these boilers since first started up has not exceeded $15.00.

In regard to their capacity we can state they are frequently run 80 per cent beyond rating and give steam of a good quality.

Altogether we find the Stirling Boilers satisfactory in every respect and the largest part of our work is done by these boilers without forcing them to their highest capacity.

Yours truly,

LOUIS C. WEYDEMEYER,
Chief Engineer.

THE SAFETY INSULATED WIRE AND CABLE CO.
Manufacturers
SEAMLESS INSULATED WIRES AND CABLES.

NEW YORK, June 4, 1895.

THE STIRLING COMPANY,
126 Liberty Street, New York City.

Gentlemen:—Answering your inquiry as to how we are satisfied with the 400 horse power Stirling Boilers, now that we have had same in use over a year, we take much pleasure in stating that these boilers have proved to be so excellent in all respects that we are free to say that when we are in the market for boilers again we shall consider no other.

Besides having fulfilled all the claims you made for them in all respects, especially as to the facility for cleaning, we have saved fuel since we abandoned our horizontal return tubular boilers, to the extent of 68 tons of coal per month.

We find they will respond very quickly to any increase in power, and that the steam is very dry. We operate the boilers under a continuous load of over 500 horse power for 10 hours per day, and at times have obtained 268 horse power from one boiler, and could obtain more power if we required same.

You are at liberty to use this letter either for publication or otherwise.

Yours very truly,

THE SAFETY INSULATED WIRE AND CABLE CO.

Per L. F. Requa, Treasurer.

OFFICE OF BLACKSTONE MANUFACTURING CO

BLACKSTONE, MASS., June 15, 1895.

MESSRS. STIRLING COMPANY,

Gentlemen :—It gives me great pleasure at this time to be able to say that the 250 Horse Power Water Tube Boiler which your Company placed in our yard about one year ago, is doing its work most satisfactorily. We have not, since starting this boiler, had to stop it for any cause at all, or had any repairs whatever. I am

Yours truly,

E. A. MONGEON, Supt.

STIRLING BOILERS IN OPERATION.

Your attention is respectfully drawn to the large number of second orders we have received. They speak for themselves.

GAS AND ELECTRIC LIGHT PLANTS.

Akron Electric Co	Akron, Ohio	600	H. P.
" " "	" " 2d order,	200	"
Barberton Electric Co	Barberton, Ohio	200	"
Jones Bros. Electric Co	Cincinnati, Ohio	300	"
Conneaut Electric Light Co	Conneaut, Ohio	160	"
Brush Electric Co	Cleveland, Ohio	500	"
Troy Gas Co	Troy, N. Y	125	"
Crookston L. & P. Co	Crookston, Minn	150	"
Hughes & Gawthorp	Pittsburg, Pa	60	"
Bell Telephone Co	Philadelphia, Pa	142	"
Edison Electric Illum. Co	Altoona, Pa	200	"
" " " "	" " 2d order,	200	"
" " " "	Martinsburg, W. Va	400	"
Indiana Electric Co	Indiana, Pa	100	"
Citizens' Electric Co	Braddock, Pa	250	"
Monongahela Electric Light Co	Homestead, Pa	150	"
" " " " " "	" 2d order,	150	"
Wilkinsburg Electric Co	Wilkinsburg, Pa	150	"
" " "	" " 2d order,	450	"
Grand Rapids Electric Co	Grand Rapids, Mich	400	"
Grand Rapids Gas Co	" " "	100	"
Escanaba Light Co	Escanaba, Mich	175	"
Auburn Mining Co	Auburn, Ind	125	"
Indianapolis L. & P. Co	Indianapolis, Ind	1500	"
Gray Electric Co	Highland Park, Ill	75	"
Pennsylvania R. R. Co	Chicago, Ill	250	"
" " "	" " 2d order,	125	"
Hyde Park E. L. & P. Co	" "	300	"
" " " " "	" " 2d order,	300	"
O. V. Bachelle	" "	100	"
Co-operative Electric Light Co	" "	500	"

Grand Forks Gas & Electric Co.	Grand Forks, N. D.	82	H. P.
Menomonie E. L. & P. Co.	Menomonie, Wis.	200	"
Madison Electric Co.	Madison, Wis.	200	"
Defiance Light & Power Co.	Defiance, Ohio	100	"
Bucyrus Electric Light Co.	Bucyrus, Ohio	125	"
Cleveland Gen. Electric Co.	Cleveland, Ohio	400	"
Hull Electric Light & Power Co.	Hull, Mass.	300	"
Hot Springs E. L. & P. Co.	Hot Springs, Ark.	250	"
Gladstone E. L. & P. Co.	Gladstone, Mich.	75	"
Excelsior Electric Co.	Port Huron, Mich.	250	"
Circleville Light & Power Co.	Circleville, Ohio	150	"
J. C. Hubinger	Keokuk, Iowa	287	"
Princeton Electric Light Co.	Princeton, N. J.	100	"
" " " "	" "	2d order, 175	"
Marion E. L. & P. Co.	Marion, Ohio	150	"
" " " "	" "	2d order, 150	"
Trinidad E. L., H. & P. Co.	Trinidad, Colo.	200	"
Bellefonte Gas Co.	Bellefonte, Pa.	200	"
Royal Electric Co.	Montreal, Que.	500	"
Hyde Park Electric Light Co.	Hyde Park, Mass.	200	"
" " " " "	" " "	2d order, 200	"
Minneapolis Gen. Electric Co.	Minneapolis, Minn.	750	"
" " " "	" "	2d order, 1500	"
Edison Light Co.	Grand Rapids, Mich.	400	"
" " "	" " "	2d order, 200	"
" " "	" " "	3d order, 1000	"
City of Kalamazoo	Kalamazoo, Mich.	250	"
North River Electric Light Co.	New York, N. Y.	300	"
Edison Electric Illum. Co	Bellefonte, Pa.	125	"
" " " "	" "	2d order, 150	"
" " " "	Paterson, N. J.	2634	"
Plainfield Gas & Elec. Light Co.	Plainfield, N. J.	400	"
Wilkesbarre Electric Light Co.	Wilkesbarre, Pa.	900	"

PUBLIC BUILDINGS, SCHOOLS, ETC.

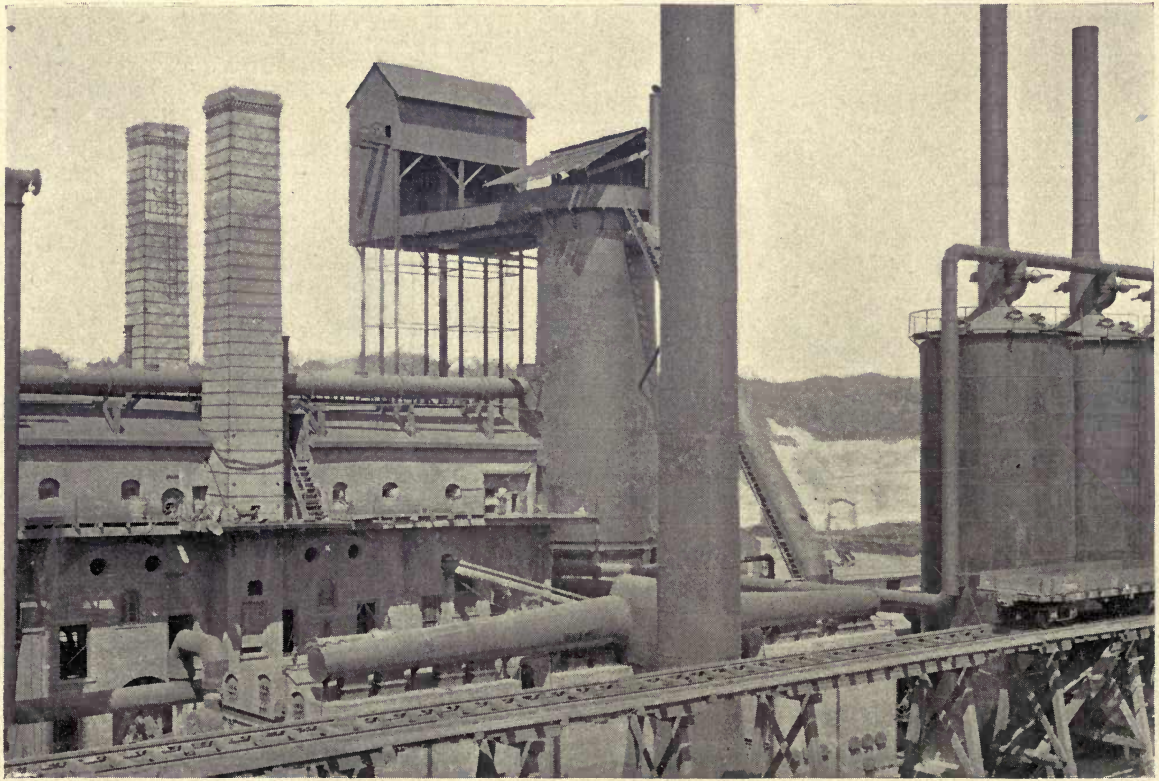
Cutting Estate	New York	60	H. P.
" "	" "	2d order, 150	"
Presbyterian Hospital	" "	300	"
" "	" "	2d order, 300	"
Lancashire Insurance Co	" "	84	"
Mail and Express Building	" "	450	"
John Pettit	" "	100	"
Imperial Fire Insurance Co.	Philadelphia, Pa.	34	"
James Callery & Co	New York	150	"

Despatch Publishing Co	Pittsburg, Pa	300	H. P.
Times Building	" "	412	"
Mills Building	San Francisco, Cal	450	"
The Olympic Club	" " "	100	"
The Donahue Building	" " "	100	"
Y. W. C. Ass'n Building	Brooklyn, N. Y	100	"
Hartman Building	Grand Rapids, Mich	125	"
Cooper Building	Denver, Colo	200	"
Midland Hotel	Kansas City, Mo	250	"
Knight Building	Ashland, Wis	132	"
National Home, D. V. S	Leavenworth, Kan	600	"
Shea Smith	Chicago, Ill	75	"
Armour Institute	" "	400	"
" "	" " 2d order,	400	"
University of Illinois	Champaign, Ill	50	"
" " Nebraska	Lincoln, Neb	150	"
" " Michigan	Ann Arbor, Mich	40	"
Michigan Mining School	Houghton, Mich	58	"
Tulane University	New Orleans, La	150	"
Reed's College	San Francisco, Cal	37½	"
Parkersburg High School	Parkersburg, W. Va	75	"
Ashland High School	Denver, Colo	150	"
Woman's Hospital	San Francisco, Cal	41	"
Hennen Building	New Orleans, La	250	"

AGRICULTURAL IMPLEMENTS AND WOOD WORKING.

Bodley Wagon Works	Staunton, Va	200	H. P.
Milburn Wagon Works	Toledo, Ohio	300	"
Galion Lumber Co	Galion, Ohio	100	"
Defiance Box Co	Defiance, Ohio	66	"
Taylor Chair Co	Bedford, Ohio	150	"
Whitman & Barnes Mfg. Co	Akron, Ohio	100	"
" " " " "	" " 2d order,	1000	"
Diamond Match Co	" "	600	"
" " "	Oswego, N. Y	600	"
" " "	Detroit, Mich	400	"
W. Michigan Furniture Co	Holland, Mich	200	"
Belknap Wagon Co	Grand Rapids, Mich	75	"
Capital Wagon Works	Ionia, Mich	160	"
Walter A. Wood Har. Co	St. Paul, Minn	600	"
" " " " "	" " 2d order,	500	"
Beebe Mfg. Co	Racine, Wis	80	"
J. I. Case Thr. Mach. Co	" "	300	"

PACIFIC COAST AGENT.



THE POUGHKEEPSIE IRON CO.'S FURNACES, POUGHKEEPSIE, N. Y., IN WHICH 1200 H. P. STIRLING BOILERS ARE INSTALLED. THE PHILADELPHIA ENGINEERING CO., ENGINEERS.

T. H. Grigg	Philadelphia Pa	50	H. P.
Adriance, Platt & Co	Poughkeepsie, N. Y	250	"
Illinois Chair Co	Rockford, Ill	100	"
Emerson, Talcott & Co	" "	200	"
Mutual Wheel Co	Moline, Ill	160	"
Brose & Baumgartner	New Washington, Ohio	66	"
Perkins & Co	Grand Rapids, Mich	62½	"

CABLE AND ELECTRIC STREET RAILWAYS.

Peoples Elec. Ry. Co	Nanticoke, Pa	150	H. P.
Second Av. Electric Ry. Co	Pittsburg, Pa	200	"
Pittsburg & W. End Elec. Ry	" "	620	"
Braddock & Turtle C. Ry	Braddock, Pa	200	"
Beaver Val. Traction Co	Beaver Valley, Pa	200	"
Lehigh Valley T. Co	Allentown, Pa	900	"
Jamestown St. Ry. Co	Jamestown, N. Y	300	"
Yonkers Railroad Co	Yonkers, N. Y	240	"
" " "	" " 2d order,	200	"
" " "	" " 3d order,	300	"
San F. & S. M. Ry. Co	San Francisco, Cal	1250	"
Los Angeles Ry. Co	Los Angeles, Cal	1500	"
Waco Elec. Ry. & L. Co	Waco, Texas	300	"
" " " "	" " 2d order,	150	"
" " " "	" " 3d order,	150	"
San Antonio Ry. Co	San Antonio, Texas	200	"
Minneapolis St. Ry	Minneapolis, Minn	575	"
" " "	" " 2d order,	2000	"
Evansville St. Ry	Evansville, Ind	750	"
St. Joe & B. H. Electric Ry	St. Joseph, Mich	400	"
Bay City Electric Ry	Bay City, Mich	400	"
South Chicago City Ry	South Chicago, Ill	1000	"
Springfield Railway	Springfield, Ohio	500	"
Toledo Con. St. Ry	Toledo, Ohio	600	"
" " " "	" " 2d order,	600	"
Cleveland City Cable Co	Cleveland, Ohio	750	"
Piqua Street Railway Co	Piqua, Ohio	100	"
" " " "	" " 2d order	100	"
Cincinnati, Cov. & Newport Ry	Cincinnati, Ohio	500	"
" " " "	" " 2d order,	500	"
Union Railway Company	New York City	500	"
" " "	" " " 2d order,	500	"
Lafayette St. Ry. Co	Lafayette, Ind	250	"
" " " "	" " 2d order,	250	"

Lindell Av. St. Ry.	St. Louis, Mo.	2700	H. P.
" " " "	" " 2d order,	675	"
Mobile Light & Power Co.	Mobile, Ala.	400	"
" " " "	" " 2d order,	300	"
Rockville & Ell'gton St. Ry.	Rockville, Conn.	200	"
Union Railway Co.	Providence, R. I.	500	"
P. & W. F. Electric Ry. Co.	Poughkeepsie, N. Y.	400	"
Belle City Electric Ry. Co.	Racine, Wis.	400	"
Portland Ry. Co.	Portland, Me.	250	"
Columbus Cent. Ry. Co.	Columbus, Ohio.	800	"
Homestead & Highland Ry. Co.	Homestead, Pa.	300	"
Philadelphia & Reading Ry. Co.	Philadelphia, Pa.	1250	"
Dundee Rapid Transit Co.	Elgin, Ill.	200	"
West Chicago St. Ry. Co.	Chicago Ill.	8000	"
Ottumwa Electric Railway	Ottumwa, Iowa	750	"
" " "	" " 2d order,	250	"
Springfield Railway Co.	Springfield, Ohio.	200	"
Pasadena & Los A. El. Ry. Co.	Los Angeles, Cal.	600	"
Elwood Electric St. Ry. Co.	Elwood, Ind.	400	"
Los Angeles Traction Co.	Los Angeles, Cal.	500	"
Detroit Railway Co	Detroit, Mich.	2000	"
Akron & C. Falls Rap. Tr. Co.	Cuyahoga Falls, Ohio.	350	"
Akron, Bedford & Cleve'd Ry. Co.	Cleveland, Ohio.	900	"
Cleveland & Elyria Ry. Co.	" "	450	"
People's Traction Co.	Nanticoke, Pa.	150	"
Shore Electric Ry. Co.	Red Bank, N. J.	300	"

SUGAR PLANTATIONS.

Leonce Soniat	Dorceyville, La.	300	H. P.
Bourdier & Bellissein	Patterson, La.	200	"
Lemann & Lum	Geary Sta., La.	400	"
D. Thompson	Patterson, La.	200	"
A. Gonsonlin	Maria Plantation, La.	250	"
John Hill	Port Allen, La.	200	"
J. H. Putnam	Abbeville, La.	200	"
Caffrey Cent. Sugar Ref. Co.	Franklin, La.	600	"
Phœnix Plntg. & Mfg. Co.	New Orleans, La.	125	"
Sugar Estate Cristobal Colon	Macoris, San Domingo	300	"
Evergreen Plantation	Iberville Parish, La.	200	"
John N. Pharr	Berwick, La.	100	"
" " "	" " 2d order,	400	"
" " "	" " 3d "	400	"
Greenwood Plantation	Bayou Lafourche, La.	150	"
Geo. M. Murrell Pltg. Mfg. Co.	Bayou Goula, La.	500	"

MINES AND SMELTERS.

Deadwood & Delaware S. Co.	Deadwood, S. D.	200	H. P.
Canadian Copper Co	Cleveland, Ohio	100	"
Grand Rapids Brass Co.	Grand Rapids, Mich.	100	"
Aurora Iron Mining Co.	Ironwood, Mich.	250	"
Ashland Iron Mining Co.	" "	150	"
" " "	" " 2d order,	150	"
Newport Mining Co.	" "	150	"
Compania Metalurg. Mex.	San Luis Potosi, Mex.	450	"
Con. K. C. Sm'g & Ref. Co.	Argentine, Kan	250	"
Centennial Eureka Mining Co.	Eureka, Utah	300	"
" " "	" " 2d order,	150	"
International Nickel Mining Co.	Riddles, Oregon	300	"
Taylor Placer Mining Co.	Grant's Pass, Oregon	150	"
The Wyant Coal Co.	Eagle, W. Va.	100	"
Acadia Coal Co.	Stellarton, N. S.	150	"
" " "	" " 2d order,	150	"
" " "	" " 3d "	550	"
" " "	" " 4th "	200	"
" " "	" " 5th "	200	"
Springside Coal Mining Co.	Pana, Ill.	75	"
Simpson & Watkins	Scranton, Pa.	450	"
" " "	" " 2d order,	200	"
" " "	" " 3d "	100	"
" " "	" " 4th "	225	"
" " "	" " 5th "	650	"
" " "	" " 6th "	400	"
" " "	" " 7th "	450	"
" " "	" " 8th "	450	"
" " "	" " 9th "	450	"
" " "	" " 10th "	400	"
Lentz, Lilly & Co.	Park Place, Pa.	250	"
L. A. Riley & Co.	Centralia, Pa.	250	"
" " "	" " 2d order,	150	"
Intercolonial Coal Co.	Westville, N. S.	300	"
Lehigh Valley Coal Co.	Wilkesbarre, Pa.	150	"
Lehigh Coal & Navigation Co.	Lansford, Pa.	400	"
" " " " "	" " 2d order,	500	"
" " " " "	" " 3d "	500	"
Lehigh & Wilkesbarre Coal Co.	Wilkesbarre, Pa.	250	"
" " " " "	" " 2d order,	250	"
" " " " "	" " 3d "	300	"
" " " " "	" " 4th "	500	"

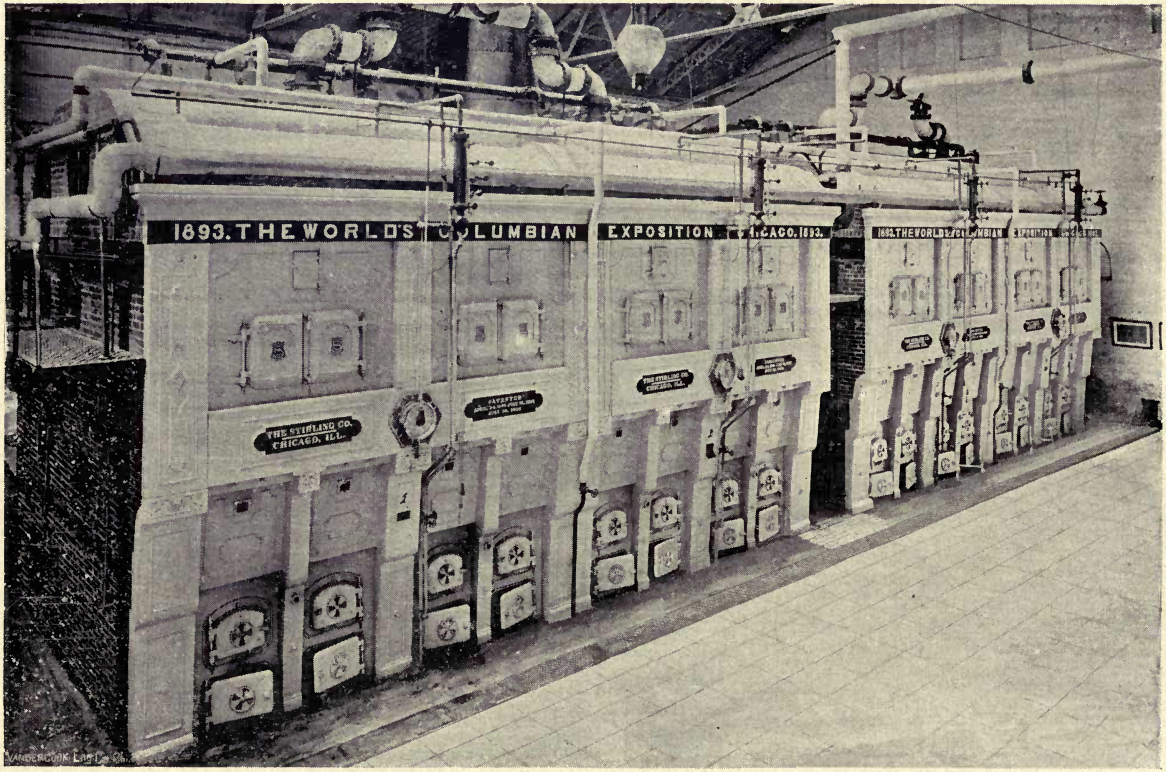
Lehigh & Wilkesbarre Coal Co.	Wilkesbarre, Pa.	5th order,	500	H. P.
" " " " "	"	" 6th "	500	"
Cross Creek Coal Co.	Drifton, Pa.		300	"
" " " "	"	" 2d order,	250	"
Silver Brook Coal Co.	Mauch Chunk, Pa.		250	"
" " " "	"	" " 2d order,	250	"
Algonquin Coal Co.	Wilkesbarre, Pa.		400	"
" " "	"	" 2d order,	250	"
Pueblo Smelt. & Ref. Co.	Pueblo, Colo.		250	"
" " " " "	"	" 2d order,	250	"
" " " " "	"	" 3d "	250	"
Penn Iron & Coal Co.	Canal Dover, Ohio		900	"
Berwind-White Coal Mining Co.	Philadelphia, Pa.		200	"
" " " " "	"	" 2d order,	200	"
" " " " "	"	" 3d "	250	"
" " " " "	"	" 4th "	200	"
Akron Mng. & Mfg. Co.	Custer, S. Dak		200	"
Midvalley Coal Co.	Wilburton, Pa.		250	"
Chamberlain Coal Co.	Port Carbon, Pa.		600	"
" " "	"	" 2d order,	600	"
Cleveland Cliffs Iron Co.	Cleveland, Ohio		500	"
Pioneer Iron Co.	Ely, Minn.		600	"

MACHINERY AND IRON AND STEEL WORKS.

Ætna Iron & Steel Co.	Bridgeport, Ohio		850	H. P.
" " "	"	" 2d order,	650	"
Ohio Iron & Steel Co.	Zanesville, Ohio		300	"
Paige Tube Co.	Warren, Ohio		200	"
" "	"	" 2d order,	400	"
Toledo Bolt & Nut Co.	Toledo, Ohio		150	"
Maumee Rolling Mill Co.	"	"	550	"
H. B. Milmine & Co.	"	"	75	"
Akron Iron Co.	Akron, Ohio		125	"
Mahoning Valley Iron Co.	Youngstown, Ohio		100	"
Lloyd Booth Co.	"	"	100	"
Solid Steel Co.	Alliance, Ohio		250	"
" "	"	" 2d order,	250	"
" "	"	" 3d order,	250	"
Falcon Iron & Nail Co.	Niles, Ohio		250	"
Eagle Iron & Steel Co.	Ironton, Ohio		400	"
Otis Steel Co., Ltd.	Cleveland, Ohio		1500	"
Standard Iron Co.	Bridgeport, Ohio		450	"
Niles Tool Works	Hamilton, Ohio		300	"

Houston, Hay & Sons	Coshocton, Ohio	150	H. P.
American Alumina Co	Barberton, Ohio	200	"
Cleveland Faucet Co	Cleveland, Ohio	100	"
Akron Heating & Ventilat'g Co.	Akron, Ohio	75	"
Montgomery Blast Furnace	Port Kennedy, Pa	425	"
" " "	" " 2d order,	400	"
Duquesne Forge Co	Rankin Station, Pa	300	"
Pennsylvania Bolt & Nut Co	Lebanon, Pa	50	"
G. W. Johnson	New Castle, Pa	250	"
Shenandoah Furnace Co	Shenandoah, Pa	500	"
Phœnix Iron Co	Phœnixville, Pa	300	"
Aliquippa Steel Works	Aliquippa, Pa	550	"
Union Iron & Steel Co	Youngstown, Ohio	600	"
Taylor Tin Plate Works	Philadelphia, Pa	150	"
Bissell & Co	Allegheny, Pa	75	"
Carnegie, Phipps & Co	Pittsburgh, Pa	1200	"
A. M. Byers & Co	" "	300	"
Shook-Anderson Mfg Co	" "	75	"
Clinton Iron & Steel Co	" "	125	"
James Irwin & Co	" "	100	"
Spang Steel & Iron Co	" "	500	"
Consol. Steel & Wire Co	" "	600	"
" " "	" " 2d order,	500	"
" " "	Allentown, Pa	500	"
" " "	St. Louis, Mo	225	"
Hamilton Ore Co	Iron Mountain, Mich	200	"
Shaw Electric Crane Co	Muskegon, Mich.	100	"
Benwood Iron Works	Benwood, W. Va	450	"
Longdale Iron Co	Longdale, Va	200	"
Joliet Enterprise Co	Joliet, Ill	300	"
" "	" " 2d order,	300	"
Clark & Windsor	" "	200	"
Ashley Wire Co	" "	700	"
Bellaire Stamping Co	Harvey, Ill	150	"
Corning Steel Co	Hammond, Ind	1000	"
M. C. Bullock Mfg. Co.	Chicago, Ill	100	"
American Tin Plate Co	Elwood, Ind	600	"
" "	" " 2d order,	500	"
" "	" " 3d order,	350	"
Nordyke & Marmon	Indianapolis, Ind	300	"
John McVoy	Muncie, Ind	75	"
Midland Steel Co	" "	550	"
" "	" " 2d order,	400	"
Indiana Iron Co	" "	300	"

SAN FRANCISCO, CAL.
PACIFIC COAST AGENT.



2400 H. P. STIRLING BOILERS AT WORLD'S COLUMBIAN EXPOSITION, CHICAGO, 1893.

West Superior S. & I. Co	West Superior, Wis	450	H. P.
" " "	" " " ...2d order,	500	"
Minneapolis & St. Louis Sm. Co.	Minneapolis, Minn	200	"
Troy Malleable Iron Co	Troy, N. Y	100	"
Poughkeepsie Iron Co	Poughkeepsie, N. Y	1200	"
Gilbert Car Co	Troy, N. Y	150	"
North Carolina I. & S. Co	Greensboro, N. C	500	"
Sioux City Engine Works	Sioux City, Iowa	224	"
Glazier Stove Co	Chelsea, Mich	66	"

FLOUR, RICE AND CEREAL MILLS.

Lyon, Clement & Greenleaf	Wauseon, Ohio	150	H. P.
National Milling Co	Toledo, Ohio	400	"
" "	" " ...2d order,	200	"
Bechtol, Carney & Co	" "	100	"
Heffner & Co	Circleville, Ohio	125	"
American Cereal Co	Akron, Ohio	400	"
Sioux Falls Milling Co	Sioux Falls, S. D	80	"
Eureka Milling Co	" "	75	"
Eldred Mill Co	Jackson, Mich	150	"
Walsh DeRoo Milling Co	Holland, Mich	175	"
J. H. Hertsche	Hamburg, Iowa	150	"
Thompson & Johnson	Fisher, Minn	125	"
Barclay Mfg. Co	West Superior, Wis	100	"
Ernst & Co	New Orleans, La	200	"
Planters Rice Mills	" "	125	"
Sparks Milling Co	Alton, Ill	150	"
Yaeger Bros	Waverly, Ill	225	"
Marshall-Kennedy & Co	Pittsburgh, Pa	600	"
D. W. Marmon	Noblesville, Ind	100	"
"	" " ...2d order,	100	"
J. Johnson & Co	New Richmond, Wis	125	"
Cleveland Milling Co	Cleveland, Ohio	200	"
North Dakota Milling Co	Grand Forks, N. D	125	"
C. W. McDaniel	Franklin, Ind	66	"
Wm. Cadick & Son	Grand View, Ind	100	"

MISCELLANEOUS.

Land & River Imp. Co	West Superior, Wis	60	H. P.
" " "	" " ....2d order,	100	"
" " "	" " ....3d order,	100	"
" " "	" " ...4th order,	70	"
Story Bros	Milwaukee, Wis	100	"

Buena Vista Fire Clay Co.	Buena Vista, Va.	100	H. P.
Creedmore Cartridge Co.	Barberton, Ohio.	75	"
The Frasch Soda Co.	Cleveland, Ohio.	800	"
Cincinnati Water Works	Cincinnati, Ohio	1200	"
Myer Packing Co.	" "	400	"
The Watt Car Wheel Co.	Barnesville, Ohio.	125	"
Toledo Water Works	Toledo, Ohio.	1200	"
Woolson Spice Mills.	" "	125	"
United Salt Co.	Cleveland, Ohio.	400	"
" "	" " 2d order,	200	"
" "	" " 3d order,	600	"
Crystal Ice Co.	Youngstown, Ohio	100	"
Robinson Bros. & Co.	Akron, Ohio.	400	"
United States Baking Co.	Mansfield, Ohio.	50	"
Vindicator Printing Co.	Youngstown, Ohio	50	"
Akron Water Works.	Akron, Ohio.	87½	"
American Strawboard Co.	Lima, Ohio.	975	"
City Water Works	Evansville, Ind.	300	"
The Toledo Bee	Toledo, Ohio	87½	"
The Buckeye Electric Co.	Cleveland, Ohio.	100	"
Produce Cold Storage Ex.	Chicago, Ill.	500	"
Wabash Paper Co.	Wabash, Ind.	300	"
J. G. Mattingly Co.	Louisville, Ky.	350	"
" "	" " 2d order,	750	"
J. B. Wathen Bros. Co.	" "	350	"
Goebel Brewing Co.	Detroit, Mich.	250	"
Barrett Brewing Co.	Cleveland, Ohio.	150	"
Maltase Mfg. Co.	Philadelphia, Pa.	100	"
Camp & Thompson	Greentown, Ohio	200	"
" "	" " 2d order,	250	"
" "	Cuyahoga Falls, Ohio. 3d order,	250	"
Merchants Cold Storage Co.	New York.	600	"
New York Carbon Co	"	75	"
Knickerbocker Press	"	100	"
Safety Ins. Wire Co.	"	400	"
L. S. & J. H. Lawless	Brooklyn, N. Y.	62½	"
Oakes Mfg. Co.	Steinway, L. I., N. Y.	350	"
Palmetto Fibre Co.	Frederick, Md.	75	"
Wm. C. Hamilton & Sons	Philadelphia, Pa.	300	"
" " "	" " 2d order,	375	"
Griffin Enam. Brick Co.	Perkiomen, Pa.	75	"
Ferrous Chemical Co.	Pittsburgh, Pa.	75	"
Coplay Cement Co.	Coplay, Pa.	600	"

John Heald & Co.	Lynchburg, Va.	360	H. P.
Poor Bros.	Salem, Mass.	100	"
National Sewer Pipe Co.	Akron, Ohio.	1065	"
Havemeyer Sugar Refinery	New York.	45	"
Salina Paper Co.	Salina, Kan.	320	"
" "	" " 2d order,	250	"
John Morrell & Co.	Ottumwa, Iowa.	200	"
Clinton Steam Laundry	Clinton, Iowa	50	"
Armour Packing Co.	Kansas City, Mo.	1000	"
" " "	" " "	1666	"
Armour Glue Works	Chicago, Ill.	1050	"
Armour Packing Co.	" "	700	"
American Glucose Co.	Peoria, Ill.	250	"
Town of Nappanee	Nappanee, Ind.	100	"
Jno. F. Betz Brewing Co.	Philadelphia, Pa	425	"
Beckman & Co.	Cleveland, Ohio	300	"
F. Gray & Co.	Piqua, Ohio	200	"
Columbus Woolen Mfg. Co.	Columbus, Ohio.	75	"
Chas. Heap	Williamstown, Mass.	300	"
Blackstone Mfg. Co.	Blackstone, Mass.	250	"
Lister Mfg. Co.	Jamestown, N. Y.	300	"
Elmira Knitting Mills	Elmira, N. Y.	50	"
Hope Company	Hope, R. I.	100	"
Bethlehem Silk Co.	Bethlehem, Pa	125	"
Geo. Singleton	Scranton, Pa.	60	"
E. B. Eddy Co	Hull, Canada.	200	"
Ohio & Pittsburgh Milk Co.	Pittsburgh, Pa.	250	"
Ohio Strawboard Co.	Urbana, Ohio.	800	"
James J. Regan	Rockville, Conn	250	"
B. F. Goodrich Co	Akron, Ohio	300	"
" " "	" " 2d order,	300	"
City of Norfolk	Norfolk, Va.	150	"
Western Elec. Supply Co.	St. Louis, Mo.	100	"
C. F. Foote	Ipava, Ill.	75	"
McCahan Sugar Refining Co	Philadelphia, Pa.	1500	"
" " " "	" " 2d order,	500	"
" " " "	" " 3d order,	900	"
Grand Rapids Felt Boot Co.	Grand Rapids, Mich.	150	"
General Fire Extinguisher Co.	Providence, R. I.	100	"
Edward Butts	City of Mexico, Mexico	100	"
Standard Radiator Co.	Buffalo, N. Y.	300	"
F. W. Cook Brewing Co.	Evansville, Ind.	250	"
Joseph L. Ebner	Vincennes, Ind.	200	"

Waltham Bleachery & Dye Wks.	Waltham, Mass.	1500	H. P.
Standard Oil Co.	Cleveland, Ohio.	400	"
" " "	" " 2d order,	1000	"
G. H. Hammond Co.	South Omaha, Neb.	400	"
" " "	" " " 2d order,	400	"
" " "	Hammond, Ind. 3d order,	500	"
Baldwin Piano Co.	Cincinnati, Ohio.	100	"
Greenpoint Chemical Works	Greenpoint, L. I., N. Y	125	"
Croxton, Kinney & Pilliod	Angola, Ind.	150	"
Krippendorf, Ditman & Co.	Cincinnati, Ohio.	600	"
Deering Harvester Co.	Chicago, Ill.	225	"
Republic Milling Co.	Republic, Mo.	175	"
J. H. Tangeman Co	Lockland, O.	160	"

J. T. McCROSSON
234 MONTGOMERY
SAN FRANCISCO, CAL.
PACIFIC COAST AGEN

UNITED STATES.

Department F.—Machinery.

1647

Exhibitor—Stirling Co. *Address* Chicago, Ill.

Group 69 *Class*: 413.

Exhibit—Water Tube Steam Boilers.--

AWARD

Furnishing steam for use of Exhibition. One of the chief characteristics lies in the simplicity and consequent low cost of construction. Boilers consist merely of four cylindrical shells or drums, connected by tubes which form major portion of heating surface. Tubes are expanded into drum, and practically the only machine work required upon entire structure is that employed upon the manhole frame in the head of each drum, which is of the simplest character. Tubes are located in a position slightly inclined from a vertical and the tendency of sediment to collect on either the exterior or interior surfaces is thereby reduced to a minimum. The large mud-drum, located below the current produced by circulation, insures quiet water in which mud, scale and other impurities may settle. Drum favorably located at bottom of rear bank of tubes for receiving deposits which require high temperature to be precipitated. Examination of these boilers in operation where water used contained large quantities of lime salts, demonstrated that a small amount of labor was required to maintain them in a clean condition, and that they operated with the highest efficiency in this most important feature and possessed marked advantage. Arrangement of division plates is such that exit for waste gases is over surfaces where the cold feed water is just entering, insuring low flue temperature. Use of a fire-brick arch covering grate enables high furnace temperature to be maintained. These boilers are proportioned so that the ratio of horse power to grate is about fifty to one, ample for economical result. Boilers exhibited show that they gave practically dry steam. Inner and outer rowsof tubes slightly curved. A chain scraper is passed through when deposits form on surfaces. The tubes are accessible from outside. A single workman disconnected the four manhole plates and exposed every tube in the boiler within a period of five minutes.

Extreme simplicity and low cost of construction of water tube boilers. Excellence of design in features pertaining to fuel economy, and singular adaptability to situations requiring the use of impure feed water.

(Signed) Geo. H. Barrus,
Individual Judge.

Approved: John A. Roche,
President Departmental Committee.

Approved: John Boyd Thacher
Chairman Executive Committee on Awards.

opyist A. M. C. *Date* February 26 1894.

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